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REPORT TO CONGRESS

THE COST OF WASTE DISPOSAL: LIFE CYCLE COST ANALYSIS OF DISPOSAL OF DEPARTMENT OF ENERGY LOW-LEVEL RADIOACTIVE WASTE AT FEDERAL AND COMMERCIAL FACILITIES

July 2002

U.S. Department of Energy
Office of Environmental Management

Overview of Life Cycle Cost Analysis Results

In the conference report for the 2002 Energy and Water Development Appropriations Bill, members of Congress expressed concerns regarding the Department of Energy's (DOE's) practices for disposal of low level radioactive waste (LLW). The concerns centered on DOE's use of federal versus commercial disposal facilities and the life cycle costs of each option.

To address these concerns, the Office of Environmental Management has completed a Life Cycle Cost Analysis for the Disposal of Low Level Radioactive Waste. The study presents the full life cycle cost for disposing of DOE's LLW, including waste preparation, packaging for transportation, disposal, closure, and long-term stewardship. This overview presents DOE's primary conclusions, proposed next steps, and analysis of the cost study results. The full cost study is attached at Appendix A.

Congressional Concerns:

- Do a life-cycle cost analysis, which includes packaging for transport, transportation, disposal, long-term closure and stewardship.
- DOE may be relying too much on on-site and off-site DOE disposal facilities and negatively impacting the viability of commercial disposal facilities.
- Use existing contracts for LLW disposal at commercial facilities; these may offer the lowest overall life-cycle cost for disposal of DOE LLW
- The fee system used by DOE disposal sites understates the true life-cycle cost of the facility, making comparisons to commercial alternatives difficult.

DOE manages a wide range of wastes, all categorized as LLW. These wastes range from relatively homogeneous soils, excavated during cleanup activities and lightly contaminated with few radionuclides, to complex heterogeneous solids contaminated with high concentrations of many different radionuclides, including transuranic actinides. Figure 1 shows how much of DOE's LLW falls within these broad categories of lower-activity cleanup waste versus higher-activity waste (whether legacy or newly generated). One can see that the majority of DOE's waste is lower-activity cleanup waste. DOE disposal decisions and disposal costs are fundamentally driven by these differences in the nature of DOE LLW.

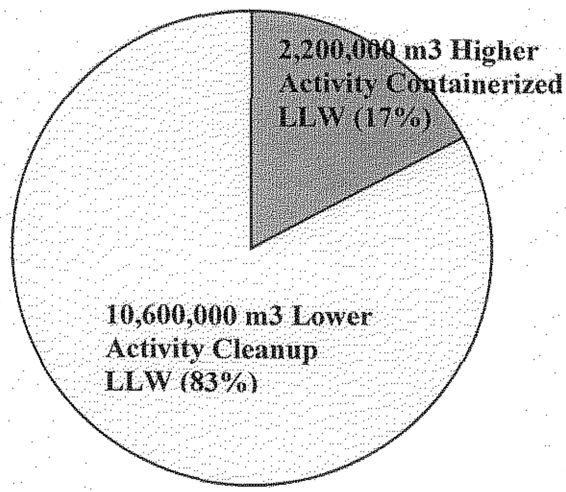
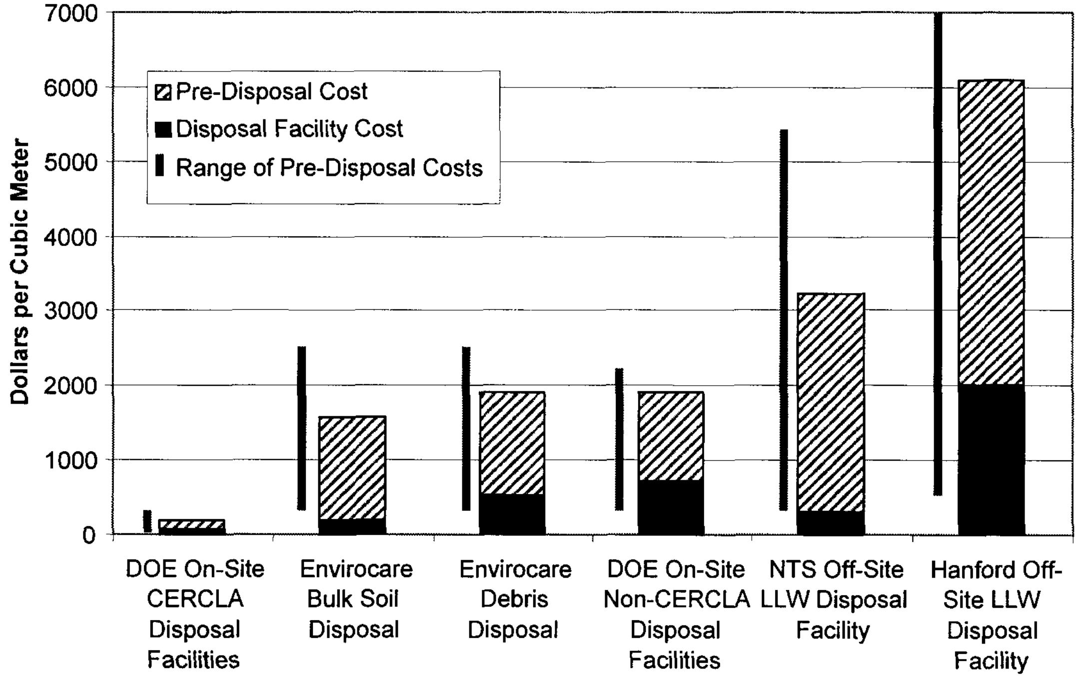


Figure 1. Source of DOE Low-Level Waste

No single facility can dispose of all of DOE's waste, and not all DOE waste is acceptable for disposal at every facility. The first step in making disposal decisions is to determine which facilities—commercial and federal—can accept the waste. It requires a partnership of federal and commercial capabilities to address the full scope of DOE's waste disposal needs. Currently, Envirocare of Utah is the commercial facility upon which DOE most depends for LLW disposal services. While the cost study analyzes life cycle costs for Envirocare as well as other commercial facilities, Envirocare currently provides DOE the most cost effective commercial disposal option. However, Envirocare's waste acceptance criteria limit acceptance of some of DOE's higher activity waste streams. The second step in making disposal decisions is to analyze the life cycle cost of disposal for that particular waste stream at each facility that can accept the stream for disposal. Use of disposal life cycle cost can only be applied as decision factor after determining that a waste is acceptable at a given facility.

Figure 2 below illustrates the basic results of the cost study: life-cycle costs per cubic meter of waste for each disposal facility. For the Envirocare, Nevada Test Site (NTS) and Hanford facilities, the bottom solid bars represent the cost to operate, close and provide long-term stewardship of the disposal facility (i.e., the costs borne by the disposal facility operator). For the other two disposal facility categories, the solid bars represent a weighted average cost (e.g., the bar for DOE On-Site Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Disposal Facilities represents a weighted average cost for DOE CERCLA facilities at Hanford, Idaho, Fernald, and Oak Ridge). The cross-hatched upper bars represent the midpoint value in the range of costs for preparing and transporting waste to the disposal facility (i.e., pre-disposal costs borne by DOE waste generator sites). The full range of predisposal costs associated with each facility is represented by a vertical line to the left of the stacked bars. These lines show the rather large range in pre-disposal costs experienced by DOE waste generators for each facility. (Note that no single waste generator pays this calculated midpoint cost; rather, generator sites each pay different costs for each stream they dispose, based on the characteristics of each specific waste stream). Sometimes these costs are relatively low to go to a given disposal facility. Sometimes these costs are relatively high to go to that same disposal facility for a different, more "difficult" waste stream.



Disposal ($/m^3)	68	180	520	710	320	2,000
Pre-Disposal ($/m^3)	130	1,400	1,400	1,200	2,900	4,100
Total ($/m^3)	200	1,600	1,900	1,900	3,200	6,100

Figure 2: Life-Cycle Unit Costs ($/m3) for DOE and Commercial Disposal Facilities

Based on the pre-disposal and disposal costs pictured in Figure 2, DOE has drawn several conclusions and defined next steps to improve management of DOE LLW.

1. Generator site pre-disposal costs offer the greatest opportunity for cost savings.

All DOE decisions for choosing LLW disposal locations should be based upon the full "cradle to grave" cost of managing the specific waste stream, not just the fee charged by the disposal facility or the cost of disposal facility operations. The waste preparation, packaging and transportation, i.e. "pre-disposal," components of the full "cradle to grave" cost of LLW disposal are the most significant portion.

1.1. Next Steps

EM sites should be directed to consider the "cradle to grave" cost for the waste stream as disposal decisions are being made. They must look beyond what the disposal facility charges and consider how using an alternative disposal facility may lower their pre-disposal costs and thereby lower the total cost.

DOE's two regional LLW disposal sites, the Nevada Test Site and the Richland site, will work together to develop and implement a standard waste acceptance process; this process will facilitate generator sites' ability to certify their waste streams for disposal at either facility and so should lower overall pre-disposal costs.

1.2. Summary Analysis

To calculate the life cycle cost to dispose of DOE waste, two categories of cost were estimated: costs to get the waste from the point of generation to the point of disposal (pre-disposal costs) and costs of operating the disposal facility (disposal costs). Pre-disposal costs include waste characterization, treatment, packaging, and transportation. Disposal costs include facility construction, operation, closure, and long-term stewardship.

Pre-disposal costs are strongly influenced by the waste's radioactive constituents, its physical form and origin, its point of generation relative to its disposal destination, and the volume of waste. Consequently, pre-disposal costs vary by individual waste stream; that is, a relatively homogeneous lower-activity waste stream requires far different preparation than a heterogeneous higher-activity legacy stream. This is reflected in the range of pre-disposal costs reported by DOE sites. As illustrated in Figure 2, each disposal facility appears to receive wastes that sometimes are quite inexpensive and other times much more expensive to prepare and transport for disposal. The cost study shows, however, that the mid-point of pre-disposal costs for each disposal location varies from approximately 60 to over 90 percent of the total life cycle disposal cost.

2. On-site DOE disposal cells for cleanup waste are cost effective.

Disposal cells constructed at DOE sites for the purpose of disposing of wastes generated during CERCLA cleanup actions are the most cost-effective alternative.

2.1. Next Steps

Expansion of existing cells or construction of new cells should be preceded by a life cycle cost analysis to assure the cost-effectiveness of the decision.

2.2. Summary Analysis

As shown in Figure 1, over the life of the cleanup program, DOE sites expect to generate approximately 10.6 million cubic meters of soil and debris from cleanup activities. These large waste quantities are lightly contaminated and do not require any special packaging or shielding to protect workers or the environment.

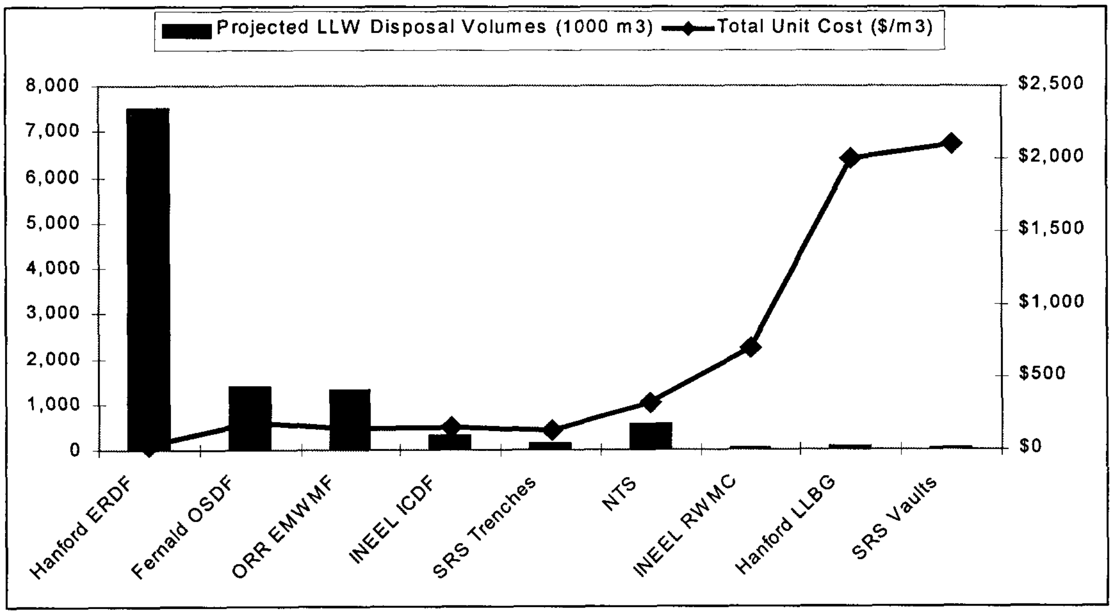


Figure 3: Life Cycle Cost (per unit of waste volume) versus Waste Volume Disposed for DOE Disposal Facilities

The on-site cells are cost effective because they benefit from economy of scale—the costs of predisposal and disposal operations are spread across a large volume of relatively "simple" waste. In addition, the need for waste packaging and transportation is minimized, further reducing life cycle costs. Figure 3 above illustrates how the life cycle cost per unit of waste at DOE disposal facilities relates to the volume of waste planned for disposal at each facility. The bars represent the projected LLW volumes planned to be disposed in each facility. The line represents the total disposal facility life cycle unit cost ($/cubic meter), based on these projected disposal volumes. Clearly, the larger the volumes to be disposed (bar), the smaller the unit cost (line). The DOE on-site CERCLA facilities shown on the left side of the figure (at Hanford, Fernald, Oak Ridge and Idaho) collectively pose lower life cycle disposal unit costs than DOE non-CERCLA facilities shown on the right side of the figure (at Savannah River, the Nevada Test Site, Idaho, and Hanford).

3. **Commercial facilities offer the lowest disposal cost for some DOE waste.**

Commercial disposal at Envirocare is a cost-effective alternative for some DOE waste and should be used to the maximum extent possible.

3.1. Next Steps

To facilitate use of licensed, commercial disposal facilities, DOE Waste Management Order 435.1 should be changed to remove the requirement for an exemption to use non-DOE disposal facilities. Instead, the Field Office Manager should be responsible for ensuring that disposal decisions are made based on technical acceptability, schedule, and cost benefit. In making these determinations, EM sites should consider the impact that alternative disposal facilities may have in reducing predisposal costs; and should consider the "cradle to grave" cost for the waste stream as decisions are being made.

3.2. Summary Analysis

The cost study considers whether DOE relies too heavily on its own facilities for disposal. Many forms of DOE waste cannot currently be disposed at Envirocare. Envirocare currently can accept only Class A equivalent waste.

As discussed in item 2 above, much of DOE's lower activity cleanup waste is currently targeted to on-site CERCLA cells, and this appears to be the most cost effective disposal option for that waste. However, recent estimates suggest over 600,000 cubic meters of LLW that cannot be disposed in on-site cells can be disposed at Envirocare. The cost study shows that for wastes acceptable for disposal there, Envirocare can provide the most cost-effective alternative, especially when the full "cradle to grave" costs (pre-disposal and disposal) for a waste stream are considered. Envirocare can accept uncontainerized waste (i.e., bulk shipments) by truck and rail; this offers DOE sites the opportunity to save on waste packaging and transportation costs. DOE's current contracts are limited to lower activity soils and debris that can be disposed of without a container.

Annually, as part of DOE's budget formulation process, each DOE site develops planning estimates of the volume of waste their site will generate and where they believe each stream will be dispositioned. These planning decisions are made at a very high planning level and do not always reflect detailed characterization of each waste stream. As a result, it is not clear that site's planning baselines currently reflect consideration of the "cradle to grave" cost of waste disposal. In fact, it is likely that many sites' planning baselines may reflect heavy consideration of the disposal facility cost (or in some cases, the fee charged by the facility), while ignoring or downplaying differences in their own costs to prepare waste for different disposal locations. Consequently, current site plans may not reflect the most cost effective overall disposal configuration. Giving guidance to DOE sites to consider "cradle to grave" costs in making disposal decisions on individual waste streams will better ensure that sites implement the most cost effective waste disposal options.

4. DOE disposal sites offer services not available commercially.

Without DOE disposal facilities, some DOE waste would not have a path to disposal. DOE's disposal facilities, especially those that accept waste from other DOE sites, provide the needed disposal capability for the full range of waste generated by DOE.

4.1. Next Steps

While DOE non-CERCLA disposal facilities are important to completing the EM mission, it is essential to continually assess and implement opportunities to reduce cost at these facilities.

4.2. Summary Analysis

DOE waste containing higher levels of activity and beta or gamma emitters is currently not accepted by Envirocare for disposal. While two other commercial disposal facilities exist that can accept higher activity waste, most DOE sites cannot access these facilities given restrictions of the Compacts. Consequently, DOE disposal of these waste streams is necessary. As shown in Figure 1, this type of waste represents approximately 17 percent of the total volume of waste expected to be managed over the life of the cleanup program. These wastes generally require additional packaging and handling, and overall are more expensive to manage. As such, these wastes drive the higher end of the pre-disposal cost ranges depicted in Figure 2 for LLW disposal at DOE facilities.

5. Comparison of disposal alternatives must consider more than just disposal fees.

DOE disposal sites charge "fees" to cover their incremental facility operation and maintenance costs (that is, DOE disposal sites charge fees, in addition to receipt of annual Congressional appropriations, to fully cover their facility operation and maintenance costs). The DOE disposal sites are limited in their ability to charge fees to cover past costs (e.g., sunk capital costs) that were funded through Congressional appropriations. DOE is also precluded from collecting fees to cover future costs (e.g., closure and long-term stewardship) without specific Congressional approval. However, the DOE practice of charging a "fee" that does not include capital costs and costs for closure and long-term stewardship does not unfairly favor DOE disposal sites as long as the "cradle to grave" cost for managing a waste stream is considered in making disposal site selections.

5.1. Next Steps

DOE disposal sites should be directed to continue calculating the fee as they have done in the past. However, DOE waste generators should evaluate the full "cradle to grave" cost of managing their waste, and base disposal decisions on that full cost.

5.2. Summary Analysis

As an example, in fiscal year 2002, DOE's Nevada Test Site (NTS) is charging generator sites an average disposal fee of \$291/cubic meter of LLW. The cost study estimates that the life cycle unit cost for LLW disposal at NTS is \$315/cubic meter (\$24/cubic meter more than what NTS currently charges in its fee, on average). However, the pre-disposal costs for waste disposed at NTS range from less than \$500/cubic meter to well over \$4,000/cubic meter. By comparison, pre-disposal costs at Envirocare range from less than \$500/cubic meter to just over \$2,500/cubic meter. The opportunity for savings clearly resides in actions that can be taken to lower the pre-disposal costs, and so emphasis should be placed on this component of the cost model.

Appendix A

THE COST OF WASTE DISPOSAL: LIFE CYCLE COST ANALYSIS OF DISPOSAL OF DEPARTMENT OF ENERGY LOW-LEVEL RADIOACTIVE WASTE AT FEDERAL AND COMMERCIAL FACILITIES

March 2002

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YAHSGS LLC
PO Box 667, Richland, Washington 99352

The Cost of Waste Disposal: Life Cycle Cost Analysis of Disposal of Department of Energy Low-Level Radioactive Waste at Federal and Commercial Facilities

March 2002

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Office of Environmental Management

Prepared by
Katherine L. Yuracko
William M. Hewitt
Scott Altmayer
Michael Raudenbush

YAHSGS LLC
PO Box 667, Richland, Washington 99352

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ABBREVIATIONS

ANL-E	Argonne National Laboratory East
ANL-W	Argonne National Laboratory West
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EMWMF	Environmental Management Waste Management Facility (Oak Ridge Reservation)
ERDF	Environmental Restoration Disposal Facility (Hanford Site)
FEMP	Fernald Environmental Management Project
FY	fiscal year
GAO	U.S. General Accounting Office
ICDF	INEEL CERCLA Disposal Facility
IPABS	Integrated Planning, Accountability, and Budgeting System
INEEL	Idaho National Engineering and Environmental Laboratory
IWMF	Interim Waste Management Facility (Oak Ridge Reservation)
LANL	Los Alamos National Laboratory
LLBG	Low-Level Burial Grounds (Hanford)
LLW	low-level radioactive waste
MLLW	mixed low-level radioactive waste
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
OMB	Office of Management and Budget
ORR	Oak Ridge Reservation
OSDF	On-Site Disposal Facility (Fernald Environmental Management Project)
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RWMC	Radioactive Waste Management Complex
SRS	Savannah River Site
WAC	waste acceptance criteria
WAG	waste area grouping
WCO	waste certification officer
WPC	waste package certifier
WSSRADF	Weldon Spring Site Remedial Action Disposal Facility

EXECUTIVE SUMMARY

This report[1] was prepared in response to language in the Conference Report on the 2002 Energy and Water Development Appropriations Bill,[2] which was preceded by expanded, more elaborate language in the House of Representatives Report,[3] text of which is set forth in the box below. Congress directed the Department of Energy (DOE) to prepare an objective analysis of the life cycle costs (i.e., the total cost to the government) of disposal of DOE's low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) for the various federal and commercial disposal options. This report sets forth the information and analyses requested by the Committee.

> ***Language from the Conference Report on the Energy and Water Development Appropriations Bill, 2002***
>
> *"Low level waste disposal.*—The conferees agree that the Department, where cost-effective, should use existing Federal contracts for the disposal of low-level and mixed low-level waste at commercial off-site disposal facilities. Further, before proceeding with any new on-site disposal cell, the Department is directed to submit to the House and Senate Committees on Appropriations an objective analysis comparing the life-cycle costs of on-site versus off-site disposal alternatives. Such analysis must address the concerns identified by the General Accounting Office in its recent report (GAO-01-441), which found that the Department has not made accurate estimates of waste volumes and transportation costs when comparing on-site versus off-site alternatives."
>
> **This language was further augmented in the House Report, which is summarized below:**
>
> ***Language from the House Report on the Energy and Water Development Appropriations Bill, 2002***
>
> The Committee is concerned that the Department is relying too heavily on the use of Federal on-site and off-site disposal cells, effectively inhibiting the development of a viable and competitive commercial disposal industry. Commercial off-site disposal facilities may offer the Department the lowest overall life-cycle cost for the disposal of this waste, particularly if the Department can foster some competition for its disposal business.
>
> The Department is directed to prepare an objective analysis of the life-cycle costs of LLW and MLLW disposal for the various Federal and commercial disposal options. This cost analysis should include the specific costs (on a unit volume of waste basis) for: preparation of the waste; packaging of the waste for transport; transportation of the waste to the disposal site; actual disposal of the waste at the disposal site; long-term closure and stewardship costs at the disposal site; and the means and timing (as measured in cost of money) for payments for disposal.

The DOE has a need to dispose of substantial quantities of LLW and MLLW as a result of past and ongoing weapons-related and research activities, as well as waste resulting from cleanup actions at DOE sites. DOE defines LLW as all radioactive waste that does not fall within other classifications such as high-level waste, spent nuclear fuel, or transuranic waste. MLLW is low-level radioactive waste with hazardous constituents, such as heavy metals and solvents, that are subject to hazardous waste regulation under U.S. Environmental Protection Agency or equivalent state regulations. LLW ranges from slightly contaminated soil and debris to waste from nuclear processes with enough radioactivity to require remote handling.

From FY 1997 through FY 1999, DOE spent over \$700 million to prepare, treat, store, and dispose of over 4 million m^3 of LLW and MLLW.[4] DOE estimates that over the next decade (FY 2001–FY 2010), it will send over 7 million m^3 of LLW and MLLW to disposal. Present estimates indicate that approximately 10 million to 15 million m^3 of LLW and MLLW must be managed for disposal

[1] This report was independently prepared by YAHSGS LLC under a subcontract to MACTEC Inc., a prime contractor to the U.S. Department of Energy.
[2] House of Representatives Report 107-258, October 30, 2001.
[3] House of Representatives Report 107-112, June 26, 2001.
[4] US General Accounting Office, "Low-Level Radioactive Wastes: Department of Energy Has Opportunities to Reduce Disposal Costs," GAO/RCED-00-64, April 2000.

over the next 70 years.[5] The majority of this waste results from cleanup activities under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). For the most part, DOE currently plans to dispose of wastes generated from CERCLA cleanup activities in designated on-site CERCLA disposal facilities. Wastes generated from ongoing operations and cleanup waste that cannot be disposed of in on-site CERCLA disposal facilities (roughly 2 million m^3) will be disposed of in LLW or MLLW disposal facilities either on site, at other DOE sites, or at a commercial disposal facility.

As a general case, DOE sites could have three options to dispose of LLW and MLLW:

1. Dispose of waste on site if suitable on-site disposal capacity is available.[6]
2. Dispose of waste at DOE's Hanford Site or Nevada Test Site (NTS).[7]
3. Dispose of waste at a commercial disposal site. Envirocare of Utah, Inc. (Envirocare) is the only commercial disposal site of any current significance to DOE's LLW and MLLW disposal needs and Envirocare has been used extensively by DOE for the disposal of LLW and MLLW.[8]

Not all DOE waste can go to all disposal sites, however. The waste acceptance criteria for the disposal sites dictate which wastes may be accepted. DOE's on-site CERCLA disposal facilities and Envirocare are limited to disposal of lower-activity wastes that represent a subset of DOE's total LLW disposal needs. Overall DOE has a very wide variety of LLW, some of which is not eligible for disposal in CERCLA disposal facilities and commercial disposal sites.

Figure ES.1 illustrates the cost elements included in the life cycle cost analysis, and Figure ES.2 summarizes the results of the analysis, expressed in cost per cubic meter of waste for each disposal facility. The bottom solid bar in Figure ES.2 represents the disposal facility cost. For Envirocare, the bottom solid bar represents the Envirocare price for disposal. Per DOE direction, the unit cost of DOE disposal facilities was calculated as the present value of future costs divided by the total waste volume to be disposed of in the facility. The calculations for DOE facilities include all future construction, operation, closure, and long-term stewardship costs for the disposal facilities from FY2002 forward and reflect all planned future waste disposal from FY2002 forward. The cross-hatched upper bars in Figure ES.2 represent the midpoint in the range of costs for preparing, packaging, and transporting waste to the disposal facility (i.e., pre-disposal costs borne by DOE waste generator sites). The full range of pre-disposal costs associated with each facility is represented by a vertical line to the left of the stacked bars.

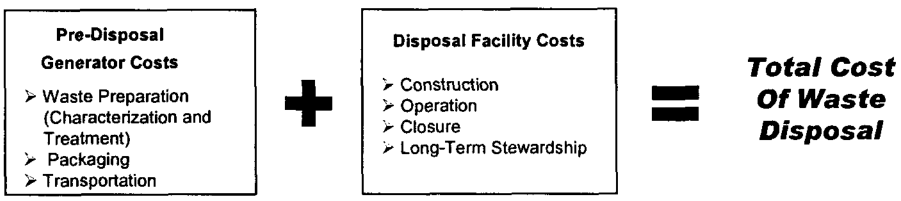

Figure ES.1. Cost Elements for DOE LLW Disposal Cost Analysis.

[5] DOE's disposal volume estimates are not firm numbers, but rather evolve as information is obtained from cleanup operations. These estimates are based on data in DOE's Integrated Planning, Accountability, and Budgeting System (IPABS) database.

[6] The following sites have on-site disposal capacity: Fernald Environmental Management Project, Hanford Site, Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, Nevada Test Site, Savannah River Site, and Oak Ridge Reservation. However, only the Hanford Site and the Nevada Test Site have the capability to dispose of all of their own waste on site.

[7] Both sites accept LLW from other DOE sites. Neither site is currently accepting MLLW from other DOE sites; however, this situation is expected to change.

[8] Other commercial disposal sites exist but have limited applicability to DOE because of state compact restrictions on the sites from which they can accept waste, high prices, or permit restrictions for only special waste types.

As illustrated in Figure ES.2, the costs that precede but are necessary to disposal (i.e., waste preparation, packaging, and transportation) vary greatly and can be significantly greater than the disposal facility cost. Thus it is essential to consider pre-disposal costs as well as disposal facility costs when making waste disposition decisions. Costs for DOE non-CERCLA on-site and off-site disposal facilities exceed those for on-site CERCLA disposal and some types of waste disposed of at Envirocare. DOE's on-site CERCLA disposal cells typically represent the lowest-cost option for wastes eligible to be disposed of in those cells. In addition, Envirocare is more cost-effective than DOE disposal alternatives for certain waste streams, depending on the specific waste characteristics. However much of the waste disposed of in the non-CERCLA on-site disposal facilities as well as waste sent to NTS and Hanford would not meet the current waste acceptance criteria for Envirocare.

Cost estimates for on-site and off-site disposal are extremely sensitive to assumptions regarding the volume of wastes needing disposal and the radioactivity level and hazardous chemical constituents in the waste, as well as duration of the cleanup, type (design) of disposal facility needed, special handling requirements, cost of off-site transportation, and price of commercial disposal. Changes in these factors could affect the balancing of costs and other factors considered while making cleanup decisions. Because of the sensitivity of decisions with regard to these factors, and the fact that the critical parameter—waste volume projections—continues to change, cost estimates should be revisited periodically as cleanup plans unfold. The U.S. General Accounting Office[9] points out that revisiting cost comparisons is especially important in instances where DOE is aware that the scope or time frame of the cleanup effort has changed dramatically.

Findings

There are ten principal findings of this study.

1. In gathering information for this study from DOE waste generators and DOE and commercial disposal sites, significant site-to-site protocol differences were apparent relative to data collection and reporting. Comparison of pre-disposal costs for different sites and wastes may not be constructive at present due to these disparities. If DOE is to use life cycle cost metrics to guide disposal site decisions, standardized protocols should be established to improve the bases for such decisions and for any subsequent audits or analyses.
2. Pre-disposal costs represent significant life cycle cost savings opportunities. Pre-disposal costs are the major cost component for all six waste disposal categories identified in Figure ES.2. Unit pre-disposal costs are strongly influenced by the radioactive constituents in the waste, the physical form of the waste, the origin of the waste, its point of generation relative to its disposal destination, and the volume of waste.[10] These factors result in substantial pre-disposal cost ranges for each disposal category listed.[11] Pre-disposal cost savings could be best realized by (a) developing a common pre-disposal cost chart of accounts for use by all waste generators, (b) reevaluating site generator pre-

[9] GAO-01-441, "DOE Should Reevaluate Waste Disposal Options Before Building New Facilities," U.S. General Accounting Office, May 2001.

[10] At one extreme might be a truck carrying one shielded cask with one cubic meter of a high activity (e.g., equivalent to Nuclear Regulatory Commission Class C) waste that can only be disposed of at Hanford or NTS that could cost tens of thousands of dollars per cubic meter. At the other end of the spectrum are millions of cubic meters of low-level wastes disposed of in an on-site CERCLA cell at Hanford for a few tens of dollars per cubic meter.

[11] Pre-disposal costs are reported in Figure ES.2 as cost ranges with an indication of the midpoint of the range, rather than as weighted average costs. Given the significant ranges of costs and the fact that data for all wastes from all sites for the period evaluated were not available, cost ranges were considered to be more meaningful than the average cost.

disposal costs on a common basis, and (c) establishing contractor incentives to reduce pre-disposal costs.

3. As recognized by the Committee, life cycle cost estimates represent an important economic metric because they represent the total cost to the government (i.e., they include "hidden" costs such as costs that are budgeted for separately). In particular, when evaluating the most cost-effective method for waste disposal, costs for waste preparation, packaging, and transportation must be considered in addition to the disposal facility cost in order to understand the option that truly represents the lowest cost to the taxpayer. Furthermore, the life cycle cost metric is of major relevance when deciding whether to build a new disposal facility[12] or expand an existing facility.

4. While commercial LLW and MLLW disposal services play a valuable and integral role in DOE's national site cleanup strategy, disposal at a DOE facility is sometimes the only option available for a given waste stream. Commercial disposal options do not exist for some DOE LLW and MLLW streams and there is no evidence that additional commercial disposal alternatives of relevance to DOE's LLW and MLLW disposal needs will be available in the near future.

5. On-site disposal at DOE facilities frequently provides the lowest cost option. For example, DOE's on-site CERCLA disposal cells typically represent the lowest cost option for wastes eligible for disposal in those cells.

6. Envirocare is the most viable commercial disposal alternative for DOE LLW and MLLW that fall within Envirocare's license limits, which, at present, are more restrictive than DOE's full LLW and MLLW disposal needs. Envirocare is able to accept all Class A LLW, but does not have a license permitting the disposal of Nuclear Regulatory Commission LLW Classes B and C as set forth in 10 CFR 61.[13] Envirocare has a very competitive price structure for lower-activity, contact-handled bulk LLW. Envirocare does not currently have a contract with DOE for disposal of higher-activity Class A waste, therefore, whether Envirocare would provide a competitive alternative for higher-activity Class A waste cannot be discerned at this time.[14]

7. With only one viable commercial vendor, DOE's commercial disposal pricing cannot be reasonably predicted beyond the current contract period.[15] DOE's current disposal contract prices at Envirocare are also reported to be considerably more favorable that those generally available to commercial waste generators. DOE represents a major customer and appears to receive volume discounts. DOE's

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[12] For example, as part of a decision on whether to build the new CERCLA disposal facility at Idaho National Engineering and Environmental Laboratory, DOE compared the life cycle cost of disposal on site with the cost of disposal at a commercial facility. That analysis provided useful input in determining whether on-site CERCLA disposal was more advantageous than using off-site disposal. DOE also effectively used cost analysis in deciding to stop using the Interim Waste Management Facility in Oak Ridge because it determined that use of that facility is not cost-effective.

[13] While these higher-activity and, in some cases, "remote-handled" wastes represent a relatively small volume, they also require expensive handling and disposal capabilities.

[14] Significant costs are associated with higher-activity and remote-handled waste. Envirocare did not share its commercial waste pricing strategy for these wastes with the analysts preparing this report when questioned in that regard. Although this is not intended to be negative in any way (Envirocare typically requires that its commercial rates not be disclosed as a contract condition), it does not provide any basis for estimating the viability of Envirocare for higher-activity DOE wastes.

[15] Historically, commercial radioactive waste disposal prices have fluctuated based on operating costs, projected waste volumes, host state tax levies, and competition for the available wastes. Were it not for the availability of internal disposal options, commercial disposal prices for DOE could conceivably be based on commercial pricing schedules for customers having similar waste types and waste volumes that lack alternative disposal outlets. This could conceivably result in disposal prices substantially higher than DOE currently pays. With only one commercial disposal company offering a viable alternative to some DOE disposal needs and the pricing of that alternative being uncertain, DOE must use significant judgment when comparing DOE costs to the commercial option.

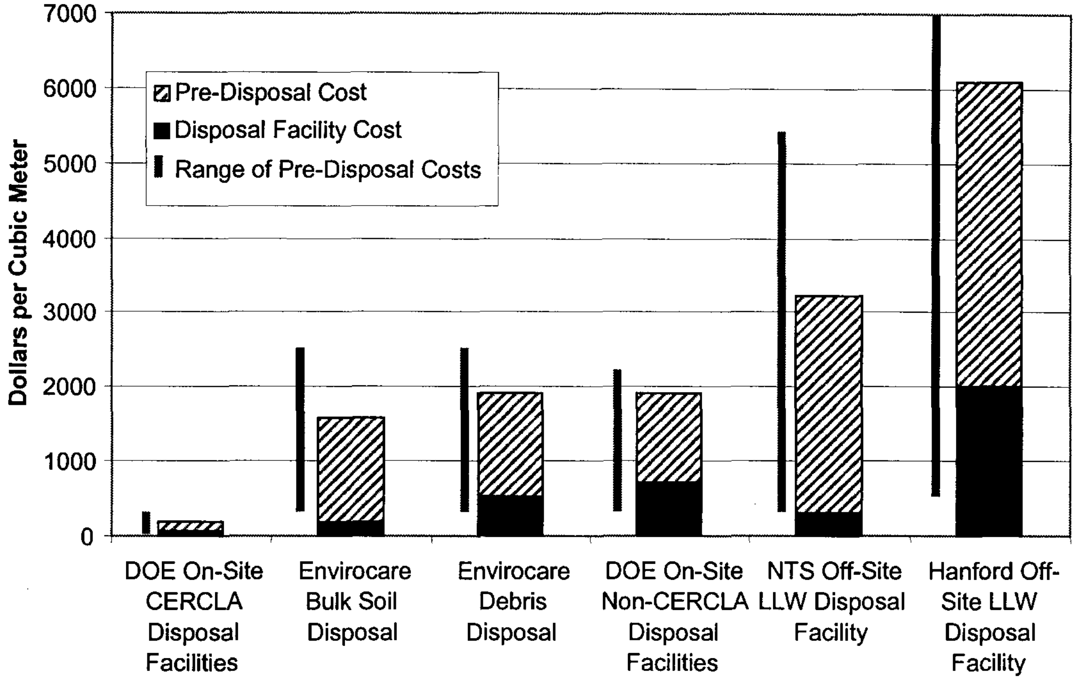
current favorable commercial pricing is also likely to be at least partially a result of the availability of DOE's own disposal sites.

8. Disposal facility costs are extremely sensitive to disposal volumes—the larger the disposal volumes, the lower the per-unit-volume cost, and changes in quantity disposed of at any site can dramatically change the cost for that site. For example, the life cycle cost of the Hanford CERCLA facility, ERDF, is substantially lower than that of other DOE or commercial facilities because of economies of scale from the enormous volumes of waste that facility handles. DOE projects that 7.5 million m^3 of waste will be disposed of in ERDF from FY 2002 through FY 2042. For comparison, DOE projects that 320,000 m^3 will be disposed of in the DOE Idaho CERCLA cell and 1.3 million m^3 in the DOE Oak Ridge CERCLA cell.

9. Hanford's LLW disposal cost for non-CERCLA wastes is significantly higher than that at NTS. The higher cost results from a combination of factors: maintaining a full service capability for all LLW waste types and activity levels, catering to small DOE waste generators with unusual/difficult to handle wastes (e.g., research wastes with unusual characteristics), and receiving lower volumes of waste (approximately 13% of the volume disposed of at NTS). Hanford's disposal costs are competitive with LLW disposal rates charged by commercial facilities with full LLW Class A, B, and C licenses (i.e., the full-service commercial LLW disposal sites in Barnwell, South Carolina, and Richland, Washington). The Hanford and NTS LLW disposal rates are also generally less than those proposed for LLW compact facilities that have not yet materialized.

10. Hanford, NTS, and Envirocare all appear to fill necessary roles in DOE's cleanup of its sites, as do DOE's on-site disposal facilities. In the same manner that DOE's disposal capabilities contribute to competitive pricing from Envirocare, so also should the economies resulting from Envirocare's streamlined waste acceptance and disposal approaches serve to remind DOE of the need to eliminate unnecessary red tape in its procedures and operations.

Data used in the report were obtained via a combination of site visits to key DOE waste generator and disposal sites and written information provided by the sites visited and others in response to a DOE data call for the purposes of this report, and by a site visit and information provided by the most viable commercial disposal alternative, Envirocare. Entities that provided substantial information used in the preparation of this report, both DOE and commercial, were provided a draft of this report for review to ensure the accuracy of the information used in the analysis.



Disposal ($/m³)	68	180	520	710	320	2,000
Pre-Disposal ($/m³)	130	1,400	1,400	1,200	2,900	4,100
Total ($/m³)	200	1,600	1,900	1,900	3,200	6,100

Notes:

1. The pre-disposal cost indicated is the mid-point value in the range. Pre-disposal cost data used for this study did not include every waste stream and did not support calculation of a weighted average value for all DOE waste streams
2. The higher pre-disposal costs indicated are due to smaller waste quantities and/or higher-activity wastes.
3. Pre-disposal costs do not reflect costs for remote-handled LLW. Costs for off-site disposal of remote-handled LLW may be much higher than indicated here.
4. For DOE on-site CERCLA disposal facilities, the pre-disposal cost range indicates the range of costs for the two operating CERCLA disposal facilities: Hanford ERDF and Fernald OSDF (the Oak Ridge and INEEL CERCLA disposal facilities are not yet operating). The disposal facility cost is the weighted average cost of the four CERCLA disposal facilities: ERDF, OSDF, EMWMF, and ICDF.
5. For DOE on-site non-CERCLA LLW disposal, the pre-disposal cost range indicates the range of costs reported for the SRS trenches and the Hanford Low-Level Burial Grounds. The disposal facility cost is the weighted average cost of the five facilities used for on-site non-CERLCA LLW disposal: SRS trenches, SRS vaults, INEEL RWMC, NTS (on-site generated LLW), and Hanford LLBG (on-site generated LLW).
6. For DOE off-site LLW disposal at NTS, the pre-disposal cost range indicates the range of costs reported for LLW shipped to NTS from Oak Ridge Reservation, Fernald, and Paducah. The disposal facility cost is the cost of the NTS LLW disposal facility.
7. For DOE off-site LLW disposal at Hanford, the pre-disposal cost range indicates the range of costs reported for LLW shipped to Hanford from ETEC and the Chicago Operations Office. The disposal facility cost is the cost of the Hanford Low-Level Burial Grounds.

Figure ES.2. Costs of LLW Disposal Including Pre-Disposal Costs of Waste Preparation, Packaging, and Transportation, and Disposal Facility Costs Including Construction, Operation, Closure, and Long-Term Stewardship.

1.0 INTRODUCTION AND OBJECTIVE

This report was prepared in response to specific language in the Conference Report on the 2002 Energy and Water Development Appropriations Bill,[16] which was preceded by expanded, more elaborate language in the House of Representatives Report.[17] Congress directed the U.S. Department of Energy (DOE) to prepare an objective analysis of the life cycle costs (i.e., the total cost to the government) for disposal of DOE's low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) for the various federal and commercial disposal options. They also directed DOE to update its analysis of on-site and off-site disposal costs before constructing the planned Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) disposal cell at DOE's Idaho National Engineering and Environmental Laboratory (INEEL).[18]

The Committee expressed concern that DOE may be relying too heavily on DOE-owned disposal facilities, thereby inhibiting viable and competitive commercial disposal options and potentially increasing the cost to the government. The Committee further expressed concern that DOE's LLW and MLLW disposal fee structures understate the true life cycle cost of disposal at DOE facilities, making a fair comparison with commercial disposal alternatives impossible. Accordingly, the Committee directed DOE to prepare a cost analysis, taking care to ensure that the full life cycle costs of disposal are taken into account. The Committee directed DOE to:

> *...include the specific costs (on a unit volume of waste basis) for: preparation of the waste; packaging of the waste for transport; transportation of the waste to the disposal site; actual disposal of the waste at the disposal site; long-term closure and stewardship costs at the disposal site; and the means and timing (as measured in cost of money) for payments for disposal*

This report sets forth the information and analyses requested by the Committee.

1.1 Background

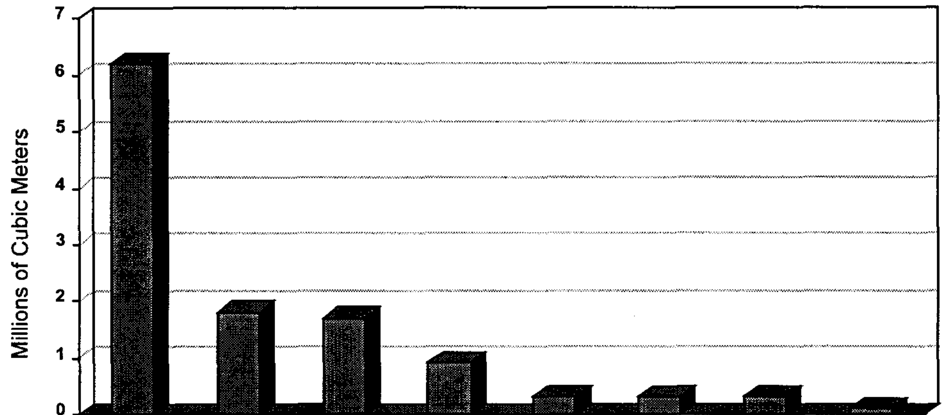
The DOE has a need to dispose of substantial quantities of LLW and MLLW as a result of past and ongoing weapons-related and research activities, as well as waste resulting from cleanup actions at DOE sites. DOE defines LLW as all radioactive waste that does not fall within other classifications such as high-level waste, spent nuclear fuel, or transuranic waste. MLLW is LLW with hazardous constituents such as heavy metals and solvents which are subject to hazardous waste regulation under U.S. Environmental Protection Agency or equivalent state regulations. LLW can range from slightly contaminated soil, debris, contaminated equipment, protective clothing, rags, and packing material to waste from nuclear processes and sealed sources with enough radioactivity to require remote handling. Remote handling creates a breakpoint where costs escalate because of the need for special equipment, more rigorous procedures and oversight, and significantly greater time and effort to complete tasks.

Before 1979, DOE routinely used commercial facilities for disposal of its LLW and MLLW to promote the development of commercial disposal facilities and provide disposal capabilities for those DOE sites that could not dispose of their wastes on site. However, between 1975 and 1978, three of the six existing commercial LLW disposal facilities closed,[19] and access to the remaining commercial facilities was

[16] House of Representatives Report 107-258, October 30, 2001.
[17] House of Representatives Report 107-112, June 26, 2001.
[18] Ibid.
[19] Maxey Flats, KY, Sheffield, IL, and West Valley, NY closed between 1975 and 1978; Beatty, NV, closed in 1992.

restricted. In 1979, DOE adopted its current policy of disposing of its LLW and MLLW at DOE-owned sites to ensure the availability of reliable disposal capacity. In 1999, DOE conducted a policy analysis to evaluate the Department's use of commercial disposal facilities for LLW and MLLW. Following this analysis, DOE re-affirmed its disposal policy.[20] Based on this policy, DOE M 435.1-1,[21] *Radioactive Waste Management Manual,* states a preference for use of DOE disposal facilities for DOE radioactive waste but provides for use of commercial alternatives under certain exceptions, including cost-effectiveness. DOE waste generators routinely use commercial disposal provided by Envirocare of Utah, Inc. (Envirocare) under the exceptions provided for in DOE M 435.1-1.

From FY 1997 through FY 1999, DOE spent over $700 million to prepare, treat, store, and dispose of its LLW and MLLW,[22] DOE estimates that over the next decade it will send over 7 million m^3 of LLW and MLLW to disposal and approximately 10 to 15 million m^3 over the next 70 years.[23] The majority of this waste results from cleanup activities under CERCLA. For the most part, DOE plans to dispose of wastes generated from CERCLA cleanup activities in designated on-site CERCLA disposal facilities. Wastes generated from ongoing operations and cleanup waste that cannot be disposed of in on-site CERCLA disposal facilities (roughly 2 million m^3) will be disposed of in LLW or MLLW disposal facilities either on site, at other DOE sites, or at a commercial disposal facility. Figure 1.1 identifies the DOE sites that are the primary generators of LLW and MLLW. The three largest LLW generators, the Hanford Site and the Fernald Environmental Management Project (Fernald), and Oak Ridge each have on-site CERCLA disposal cells that can accommodate the vast majority of the wastes from those sites. Hanford represents approximately 50% of the total DOE LLW generation.



	Hanford	Fernald	Oak Ridge	Other Sites	SRS	Idaho	RFETS	NTS
M/LLW Volume	6.2	1.8	1.7	0.9	0.3	0.3	0.3	0.1

Figure 1.1. DOE M/LLW Generation Projections by Major Site, 2001–2070. *Source: Data provided by DOE Headquarters based on site input to IPABS as of August 2001.*

Table 1.1 identifies facilities available for the disposal of radioactive waste. Nominally, DOE has access to nine operating DOE disposal facilities and three commercial disposal facilities (Envirocare, Barnwell,

[20] U.S. Department of Energy, *Commercial Disposal Policy Analysis for Low-Level and Mixed Low-Level Wastes*, March 9, 1999.

[21] DOE Order 435.1 and DOE M 435.1-1, *Radioactive Waste Management* (M 435.1-1 is a manual for the implementation of DOE 435.1) provide direction to DOE regarding the management of DOE wastes.

[22] U.S. General Accounting Office, *Low-Level Radioactive Wastes: Department of Energy Has Opportunities to Reduce Disposal Costs*, GAO/RCED-00-64, April 2000.

[23] Based on data in the DOE IPABS database.

and US Ecology).[24] The available disposal facilities have a combined capacity (both waste volume and quantities and concentrations of radionuclides) that is substantially greater than the 10 to 15 millionm^3 of waste DOE plans to dispose of from ongoing operations, legacy waste, remediation, and decontamination and decommissioning (D&D) of excess facilities. This type of excess capacity is important because of uncertainties in waste volume predictions and the long lead time needed to bring new capacity on-line.

Table 1.1. Facilities for Disposal of Radioactive Waste

Status	Facility	Type of Waste			
		LLW	MLLW	11e.(2)[a]	Exempt[b]
Operating DOE Facilities	Fernald Environmental Management Project—On-Site Disposal Facility (OSDF), CERCLA	√[d]			
	Hanford Site—Low-Level Burial Grounds (LLBG)	√	√[c]		
	Hanford Site—Environmental Restoration Disposal Facility (ERDF), CERCLA	√[d]	√[c]		
	Idaho National Engineering and Environmental Laboratory (INEEL)—Radioactive Waste Management Complex (RWMC)	√[d]			
	Los Alamos National Laboratory—Area G	√[d]			
	Nevada Test Site (NTS)—Radioactive Waste Management Sites	√	√[c]	√	
	Oak Ridge Reservation—Environmental Management Waste Management Facility (EMWMF), CERCLA (*planned to open in FY 2002*)	√[d]	√[c]		
	Oak Ridge Reservation—Interim Waste Management Facility (IWMF)	√[d]			
	Savannah River Site—Vaults and Trenches	√[d]			
Planned DOE Facilities	INEEL—INEEL CERCLA Disposal Facility (ICDF), CERCLA	√[d]	√[c]		
	Paducah—Paducah Disposal Facility, CERCLA (*facility under consideration; no decision made yet*)	√[d]	√[c]		
	Portsmouth—Portsmouth Disposal Facility, CERCLA (*facility under consideration; no decision made yet*)	√[d]	√[c]		
Closed DOE Facilities	Monticello Mill Site—Monticello Disposal Facility			√	
	Weldon Spring Site—Weldon Spring Site Remedial Action Disposal Facility (WSSRADF)			√	
Commercial Facilities	Envirocare of Utah, Inc. (Utah)	√	√	√	
	Barnwell Waste Management Facility, Chem-Nuclear Systems, L.L.C. (South Carolina)	√			
	US Ecology Richland, WA Radioactive Waste Disposal Site	√			
	Waste Control Specialists (Texas)				√
	US Ecology Grand View, ID Hazardous Waste Treatment and Disposal Facility				√
	Button Willow (California)				√
	International Uranium Corporation Mining (Utah)			√	√

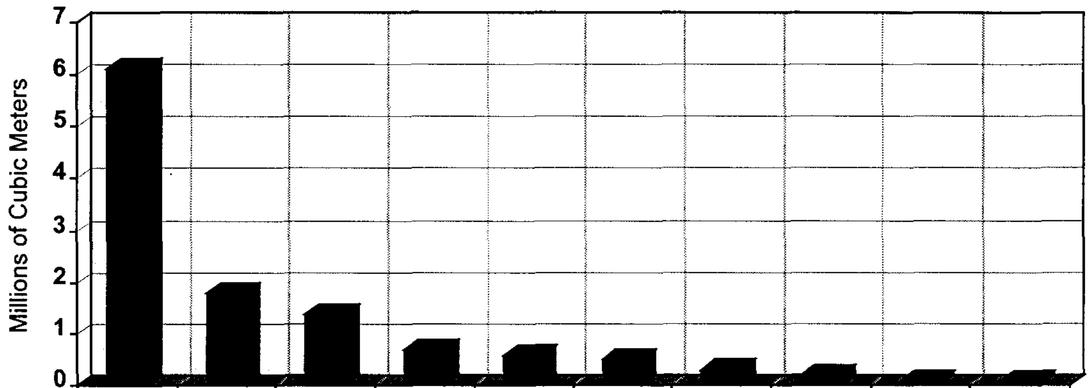
Notes: (a) 11e.(2) refers to byproduct material as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended. (b) "Exempt" generally refers to naturally occurring and accelerator produced radioactive materials that are not governed by the Atomic Energy Act of 1954. (c) These sites dispose of on-site generated MLLW. Although NTS and Hanford are anticipated to also dispose of offsite DOE MLLW in the future, they do not currently dispose of MLLW from off-site DOE generators. (d) These sites dispose of on-site generated LLW.

Seven DOE sites have on-site disposal capabilities: Fernald Environmental Management Project (FEMP), the Hanford Site, INEEL, Los Alamos National Laboratory, Nevada Test Site (NTS), Oak Ridge Reservation (ORR), and the Savannah River Site (SRS). Of these, only Hanford and NTS can dispose of all the LLW and MLLW they generate, as well as LLW from other sites. The other DOE sites cannot

[24] The four other commercial disposal facilities listed in Table 1.1 are able to receive only "exempt levels" of radioactive waste or 11e.(2) material. "Exempt" generally refers to naturally occurring and accelerator produced radioactive materials that are not governed by the Atomic Energy Act of 1954. These facilities have limited niche capabilities and are not discussed further in this report.

dispose of MLLW other than as allowed by CERCLA and can only dispose of some of their self-generated LLW.[25]

As shown in Figure 1.2, DOE currently plans to dispose of the majority of its LLW and MLLW at DOE sites. Most of this waste (over 80%) results from CERCLA activities and is disposed of in on-site CERCLA disposal facilities. Over 70% of the Department's CERCLA waste projected for on-site disposal results from planned Hanford cleanup activities. DOE has typically found on-site disposal to be the cost-effective option, when available, because it avoids the costs of waste transportation and can reduce waste treatment costs. On-site disposal is not always an option. This could occur for a variety of reasons including unsuitable geologic properties, incompatible future land uses, or other regulatory factors. In such cases, off-site disposal options must be used.



	Hanford ERDF	Fernald OSDF	Oak Ridge EMWMF	NTS	Envirocare	Other/TBD	SRS	Idaho ICDF	Idaho RWMC	Hanford LLBG
M/LLW Vol, Mil m3	6.1	1.8	1.4	0.7	0.6	0.5	0.3	0.2	0.1	0.1

Figure 1.2. DOE M/LLW Projected Disposal Site Volumes, 2001–2070. *Source: Data provided by DOE Headquarters based on site input to IPABS as of August 2001.*

For wastes to be disposed of off-site, DOE currently has three[26] major viable off-site disposal alternatives: two internal disposal facilities (at Hanford and NTS) and one commercial facility (Envirocare). As illustrated in Figure 1.3, current DOE estimates indicate that approximately 50% of the waste destined for off-site disposal is currently planned to be sent to commercial disposal facilities.

[25] SRS and INEEL both also receive wastes from the Naval Nuclear Propulsion Program sites for disposal.

[26] Other commercial LLW disposal options include a site at Barnwell, SC, and the U.S. Ecology site on the Hanford Reservation in Richland, WA; however, the pricing and protocols for those sites are generally not competitive with either internal DOE options or those of Envirocare. For example, the cost for disposal of soil in containers would be roughly \$14,000 per m^3at Barnwell and roughly \$2,000–\$3,000 per m^3at US Ecology. Other restrictions apply because of the nature of the LLW compact agreements.

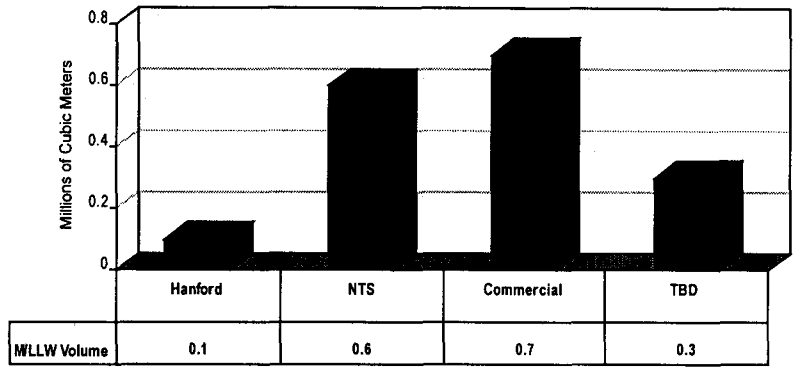
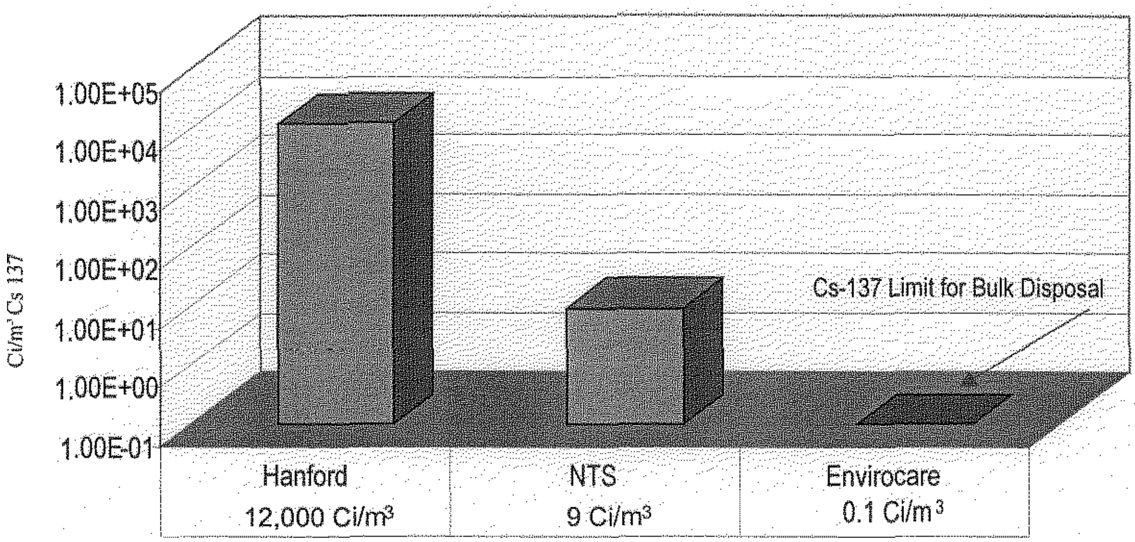


Figure 1.3. DOE M/LLW Volumes Projected for Off-Site Disposal By Disposal Facility, 2001–2070.
Source: Data provided by DOE Headquarters based on site input to IPABS as of August 2001.

For disposal of waste in any disposal facility, the waste must meet the disposal facility's waste acceptance criteria (WAC). Waste can only be disposed of in facilities, whether on-site or off-site, that have the prerequisite characteristics and regulatory approvals for disposal of that type of waste. Not all LLW can go to all disposal facilities. Both Hanford and NTS have broad waste acceptance limits to encompass higher-activity and remote-handled (greater than 200 mR/hour) wastes that are typically commensurate with NRC Class B/C wastes. NTS and Hanford both currently accept a full range of LLW. Hanford and NTS each operate a RCRA Subtitle C disposal cell for MLLW generated by on-site projects. The Subtitle C cells are not presently available for off-site wastes; however, both sites are anticipated to be able to receive off-site DOE wastes in the future.

Envirocare accepts a subset of NRC Class A waste in both its LLW and RCRA Subtitle C cells. These licenses are based on Envirocare disposing of contact-handled waste, which generally refers to waste with a contact dose of less than 200 mR/hour. This results in a license that is permissive for radionuclides that emit little or no significant gamma radiation but has very tight limits for radionuclides that are significant gamma-emitters such as, but not limited to, Co-60 and Cs-137. The license uses a "sum of the fractions" technique such that relatively small amounts of limiting radionuclides can severely restrict the quantities of other radionuclides allowed in a package or shipment. Much of DOE's waste contains sufficient gamma-emitting radionuclides and/or alpha-emitting radionuclides to preclude Envirocare as a disposal option.[27] As an illustration of the differences in the site WACs, Figure 1.4 depicts the restrictions for Cs-137 in DOE's current contract with Envirocare in comparison to the NTS and Hanford WACs.

[27] Envirocare has increased its license to permit somewhat higher radionuclide concentrations for burial under the "Containerized Class A Disposal" waste acceptance guidelines. However, such wastes will come under a separate pricing structure that has not yet been put into a DOE contract. That pricing structure is anticipated to be significantly greater than current DOE contract pricing levels because of more stringent requirements placed on Envirocare, including requirements that wastes be containerized and disposed of in totally separate disposal cells from those currently used under DOE's contract. Envirocare also has prepared an application to accept NRC Class B/C LLW and MLLW. This application has met with some public opposition, and action on the application is proceeding in accordance with the Utah statutory permitting process.



Note: NTS and Hanford values differ because the waste acceptane criteria are based on sitespecific analyses and reflect differences in site characteristics. The NS value is determined on a disposal cell basis, based on the "all pathways" exposure scenario in the NTS perforance assessment. The Hanford value is determined on a disposal cell (trench) basis, based on an inadvdent intrusion scenario in the Hanford performance assessment. At Hanford, cesium disposal provides mimal risk in the "all pathways" exposure scenario in the performance assessment because of sitespecific characteristics. The Envirocare limit refers to bulk contacthandled waste.

Figure 1.4. Comparison of DOE and Commercial Disposal Sites for a Typical Limiting Radionuclide. *Source: Envirocare License UT 2300249, Amendment #12 and Waste Acceptance Criteria for Hanford and NTS (http://emi-web.inel.gov/wac/wac.html).*

1.2 Scope and Conduct of this Study

The scope of this study includes analyzing and comparing, on a life cycle basis, the total future cost to the government associated with disposal of DOE's LLW at DOE-owned and commercial disposal facilities. Data used for this analysis were obtained from DOE and contractor personnel at waste generator and disposal sites. The study underpinning this report included site visits to representative sites: the Rocky Flats Environmental Technology Site (RFETS), INEEL, Oak Ridge Reservation, Nevada Test Site, Hanford Site, and Envirocare. Additional DOE disposal and generator site data were obtained in response to a DOE Headquarters data call to obtain cost and waste volume projections and through subsequent discussions with site representatives. Appendix E provides a list of the persons interviewed for this study. Data were reviewed to ensure completeness in including all cost areas, including waste preparation, packaging, transportation, disposal, and closure and long-term stewardship for disposal facilities. In some instances, DOE does not track costs in the same categories as were requested for this review. In such cases YAHSGS worked with DOE site representatives to appropriately categorize the subject cost elements and to ensure that comparable information was obtained from all sites.

At present, neither the Hanford nor the NTS disposal facility accepts DOE MLLW from off-site generators, and Envirocare only accepts low activity MLLW. Consequently, there is no DOE/commercial basis for comparison for MLLW, and MLLW is not discussed further in this report.

2.0 DEVELOPING AN EQUITABLE LIFE CYCLE COST BASIS FOR COMPARISON

When the commercial sector is providing a service similar to that provided by the government, private sector companies are frequently concerned that the government may create an unfair competitive environment because of the differences in commercial and federal accounting practices. Life cycle cost analysis is a method that provides a sound basis of comparison between the "true" cost of government provided services and those within the private sector, accounting for all costs anticipated to be incurred by the government. This report presents a life cycle cost analysis for waste disposal at DOE and commercial disposal facilities, including the necessary pre-disposal costs such as waste preparation, packaging, and transportation. When analyzing life cycle waste disposal costs, it is important to consider "pre-disposal" costs incurred at generator sites before waste disposal because these costs differ as a function of the selected disposal facility and, therefore, should influence the choice of disposal facility.

DOE's approach to LLW disposal has been the subject of numerous studies, as well as inquiries from the Congress. Previous disposal practice studies have been performed by DOE and by the General Accounting Office (GAO). A listing of previous investigations and reports is set forth in Appendix C. Studies by the GAO and DOE Inspector General have raised questions not unlike those raised by the Committee that are addressed in this report. Obtaining fair comparisons between DOE disposal costs and commercial pricing has not been a straightforward matter, as evidenced by the continuing questions. The difficulty in comparing DOE costs with commercial pricing is largely tied to the differences in federal and commercial accounting practices and funding protocols and the aggregate way in which DOE captures and reports its costs in its accounting systems.

Some DOE disposal facilities are funded through a combination of direct funding through annual appropriations and disposal fees charged to waste generators. Fixed costs such as construction of a disposal facility, as well as costs for disposal facility closure and long-term stewardship, are typically direct-funded through annual appropriations. Disposal fees charged by DOE disposal facilities typically relate to the facility's variable cost. Furthermore, DOE facilities typically do not budget now for future costs tied to site closure and long-term stewardship because such funds will be requested from Congress when the money is actually needed.[28]

In addition, DOE facilities dispose of some waste that would be eligible for commercial disposal and other waste that falls outside the waste acceptance criteria for commercial facilities. However, DOE facilities typically do not collect the costs associated with those wastes separately; by aggregating the costs, it is difficult to determine the costs associated with those wastes that could be disposed of in commercial facilities.

Finally, different types of costs related to waste disposal may be budgeted for separately (e.g., regulatory, security, utilities, etc.). Care must be taken to fully include all costs associated with waste disposal at DOE facilities, regardless of which account they may fall in. This study has addressed the preceding factors and other less significant factors to provide an improved basis for comparison between DOE-owned disposal sites and commercially available alternatives.

Consistent with the Committee's request, this analysis includes all direct and indirect costs related to waste disposal, including waste preparation (i.e., characterization and treatment), packaging for transport, transportation to the disposal facility, future construction and operation of the disposal facility, closure,

[28] In the absence of a special budgetary mechanism authorized by the Congress, funds for the closure and long-term stewardship of DOE disposal facilities are requested from Congress for the fiscal years in which those costs will actually be incurred.

and long-term stewardship of the waste disposal facility. Costs associated with waste generation, including remediation and D&D costs, are outside the scope of this analysis and would not discriminate among disposal facility alternatives. Figure 2.1 highlights the major categories of cost elements considered in the analysis of waste disposal costs.

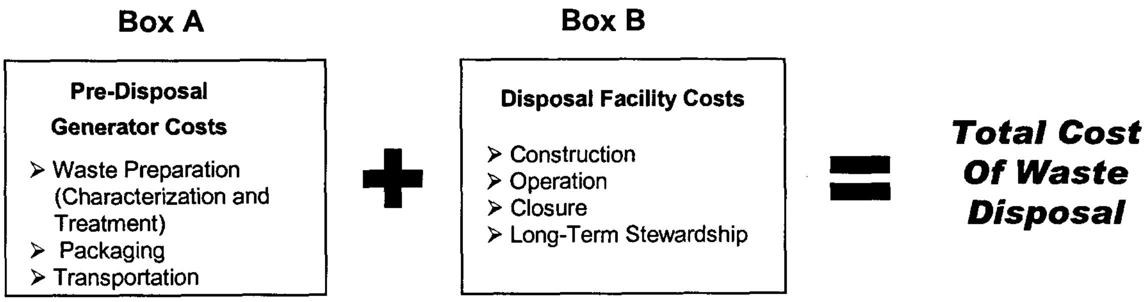


Figure 2.1. Cost Elements for DOE LLW Disposal Cost Analysis.

Pre-disposal costs (Box A) were calculated based on information obtained from a cross-section of DOE waste generator sites as described in Section 2.1. For disposal at DOE facilities, the disposal facility cost (Box B) was calculated based upon information obtained from DOE disposal sites as discussed in Section 2.2. For commercial alternatives, the cost to the government of the disposal facility (Box B) is the price to dispose of the waste at the commercial disposal facility.[29]

2.1 Waste Generator Information on Pre-Disposal Costs

"Pre-disposal costs" of waste preparation (treatment and waste characterization), packaging, and transportation are strongly influenced by the choice of disposal facility. Other important factors that influence pre-disposal costs include the waste characteristics, pedigree of knowledge associated with the waste, treatment process (e.g., cut, sort, compact, oxidize, dry), and any specific contract incentives that may exist.

The following generator sites provided detailed information on pre-disposal costs:

- ✓ Hanford Site
- ✓ Oak Ridge Reservation (East Tennessee Technology Park, Oak Ridge National Laboratory, Y-12 National Security Complex)
- ✓ Paducah Gaseous Diffusion Plant
- ✓ Fernald Environmental Management Project
- ✓ Chicago Operations Office (data provided for Argonne National Laboratory-East)
- ✓ Savannah River Site

YAHSGS conducted on-site interviews with four major waste generator sites (Hanford, INEEL, Oak Ridge Reservation, and RFETS) and conducted telephone interviews with site personnel at the remaining sites who are knowledgeable of waste characterization, treatment, packaging, and transportation. Sites typically did not collect information in these categories, and in some cases aggregate cost data were provided by the sites rather than costs broken down into these categories. Thus, the distribution of pre-

[29] The price is assumed to be the total cost to the government associated with the commercial disposal facility (i.e., it is assumed that the government will not incur any future costs arising from its potential liability for the site). As Envirocare's largest waste generator, the Federal government bears the largest share of any post-operational liabilities associated with the Envirocare site. Therefore, this may underestimate the true cost to the government.

disposal costs into the sub-elements of waste preparation, packaging, and transportation should be considered approximate.

2.2 Waste Disposal Site Information

For DOE waste disposal sites, YAHSGS gathered information on all future costs associated with construction, operation, closure, and long-term stewardship of the disposal facility. The calculations include all post-closure period disposal cell costs, irrespective of who retains title to the sites or is responsible for long-term stewardship. It is assumed that long-term stewardship (e.g., site monitoring) is required for 100 years[30] after the site is closed and capped.

Life cycle costs for DOE disposal facilities represent the present value of future costs.[31] Appendix A provides details regarding the techniques and approaches used to estimate life cycle costs, including the application of present value techniques. The actual spreadsheets used for the calculations are provided in Appendix B. Results are presented on a unit volume of waste basis. As directed by DOE, for DOE disposal facilities the unit life cycle cost was calculated as the present value of future costs divided by the total waste volume to be disposed of in the facility.

All direct and indirect costs are included in the cost estimates, regardless of whether DOE budgets for these costs today and whether waste generators are assessed these costs via DOE disposal fees. For example, although closure and long-term stewardship costs have been included in the life cycle cost estimates, DOE typically does not collect and maintain funds for future closure and long-term stewardship costs that will not be incurred for many years. In general at DOE sites, some of the costs related to waste disposal are embedded in general site support and infrastructure accounts. Sites were requested to identify and prorate all appropriate indirect costs that supported waste disposal, and those costs were included in the disposal facility cost estimates. As previously noted, YAHSGS worked with the sites to extract this data and made approximations as necessary. As a result, the estimates should be considered approximate.

Costs incurred before the present time are "sunk costs" and are excluded from this analysis; however, future costs associated with past waste disposal activities have been included in the cost estimates. In particular, closure costs are estimated based on the total volume of waste to be capped in the future, not simply the amount of waste that is emplaced from FY 2002 through closure of the facility.

It may be argued that for some sites (e.g., NTS, Hanford), long-term stewardship costs should not be included in this analysis because DOE must pay long-term stewardship costs regardless of whether another unit of waste is ever emplaced in those disposal facilities. Similarly, the future costs associated with capping waste that has already been emplaced would be incurred by DOE regardless of whether the disposal facility is used for future waste disposal. It may be argued that these are also sunk costs that should not be included in the cost estimate, because these costs must be paid by DOE whether or not future wastes are disposed of in the facility. These costs have, however, been included in the life cycle cost estimates presented in this report to fully represent the total future cost to the government.[32]

[30] The 100-year long-term stewardship time is derived from EPA regulations that limit the amount of time that long-term institutional controls can be relied upon. These limits are independent of whether the site is under federal control or state control as would be the case for Envirocare.

[31] All future costs have been calculated in constant FY 2002 dollars and discounted to the present using a real discount rate of 3.2%. A real discount rate of 3.2% is used to calculate present value, per OMB Circular No. A-94, as updated in OMB Memorandum M-01-14, March 7, 2001.

[32] The inclusion of these costs has a significant impact on the life cycle cost estimates. For example, for the Hanford LLBG, the cost of capping of previously disposed waste represents $580/m^3$ of the $2700/m^3$ disposal facility cost.

Particular uncertainty surrounds estimates of future closure and long-term stewardship costs. Because closure is expected to occur far in the future for many of DOE's disposal facilities, estimates of future closure costs are highly uncertain. Long-term stewardship costs are particularly difficult to estimate because of the limited experience in this area. Based on estimates from the NTS and Oak Ridge, YAHSGS assumed long-term stewardship costs of $500,000 per year for 100 years. This assumption was used for the five facilities [Hanford Low-Level Burial Grounds (LLBG), Hanford ERDF, INEEL RWMC, and SRS trenches and vaults] that did not provide long-term stewardship cost estimates.

2.3 Application of Life Cycle Cost Analysis

Table 2.1 summarizes the comparison of cost bases for DOE and commercial facilities for the calculation of pre-disposal costs and compares the cost bases used for the calculation of disposal facility costs for DOE and commercial facilities.

Table 2.1. Comparison of Disposal Cost Bases for DOE and Commercial Facilities

Cost Element	DOE Disposal Facility	Commercial Facility	Analysis Approach
Pre-Disposal Cost Elements			
Waste Preparation: Treatment Costs	These costs are typically related to placing wastes into a proper chemical and physical form to meet the disposal facility WAC. For DOE wastes, these costs are primarily attributable to mixed wastes that must undergo stabilization or encapsulation to meet Land Disposal Restrictions. This also includes conditioning, sizing, and drying of LLW. As such, the differences between treatment before disposal at a DOE or commercial facility are relatively minimal for similar waste types.	Treatment before disposal is offered by commercial companies, including Envirocare; Perma-Fix; Waste Control Specialists, LLC; and Allied Technology Group, Inc.	Treatment costs are included in the pre-disposal cost estimates. However, for DOE,[33] treatment costs are generally the same regardless of the disposal site used.
Waste Preparation: Characterization Costs	Waste characterization, as used in this report, includes all sampling, analysis, QA, certification, and other steps required to meet the disposal site WAC. Certification is a subset of characterization that refers to the final act of documenting and accepting the waste. Waste certification requirements vary between Hanford and NTS. Hanford confirms the waste certification as part of Hanford's waste receipt process, whereas NTS has established protocols that allow the generator/ shipper to certify the wastes before shipment.	Generators establish waste profiles for waste types. The generator tests outgoing wastes to certify they are within the profile. Envirocare performs confirmatory analyses for some fraction of the incoming waste.	Waste characterization costs borne by the generators are included in the pre-disposal cost estimates. In addition, Hanford LLW disposal facility costs include the costs of inspection or sampling of as-received wastes.
Waste Packaging Costs	DOE LLW is typically containerized, the container type and cost varying with the waste type.	Envirocare disposes of bulk soils without containers. MLLW requires containers and it is anticipated that if Envirocare accepts higher activity LLW than currently disposed of in bulk, that waste will be containerized as well.	Waste packaging costs are included in the pre-disposal waste generator cost estimates.
Waste	Off-site transportation to Hanford or NTS is by	Envirocare can accept	Transportation costs are

[33] Commercial waste generators are more prone to treat/condition LLW to reduce disposal volumes because they pay substantially higher unit volume disposal costs than are levied against DOE.

Table 2.1. Comparison of Disposal Cost Bases for DOE and Commercial Facilities

Cost Element	DOE Disposal Facility	Commercial Facility	Analysis Approach
Transportation Costs	truck, which generally results in greater costs than shipment by rail.	waste by truck or by rail.	included in the pre-disposal cost estimates based on the mode of transportation used and the distance. Roundtrip rates are used for Envirocare if containers are to be returned for reuse.
Disposal Facility Cost Elements			
Capital Costs	Historical costs are treated as sunk costs.	This information is proprietary for Envirocare and is presumed to be recovered in the pricing structure along with interest on capital.	DOE disposal facility cost estimates include all future capital expenditures.
Operating Costs	Operating costs include both direct and indirect costs. Because disposal facilities are co-located with other operating entities, there are shared costs that must be equitably allocated to the disposal facility.	This information is proprietary for Envirocare and is presumed to be recovered in the pricing structure.	DOE disposal facility cost estimates include all future operating costs.
Closure Costs	Estimated per DOE protocols and based on comparable activities at other sites.	Commercial operators are required to establish a trust fund for closure. If that fund is inadequate and the commercial company is no longer viable, waste generators could bear the liability for additional charges.	DOE disposal facility cost estimates include estimates of future closure costs.
Long-Term Stewardship Costs	Long-term stewardship costs may be estimated; however, protocols are not fully established.	Commercial operators are required to establish a trust fund for post-closure maintenance and surveillance. If that fund is inadequate and the commercial company is no longer viable, waste generators could bear the liability for additional charges.	DOE disposal facility cost estimates include estimates of future long-term stewardship costs.

3.0 LIFE CYCLE COSTS FOR WASTE DISPOSAL

As was noted in Figure 2.1, life cycle costs for disposal of DOE wastes were gathered from sites for seven major elements:

- Waste Preparation (Characterization and Treatment)
- Waste Packaging
- Waste Transportation
- Disposal Facility Construction
- Waste Disposal Operations
- Disposal Facility Closure
- Disposal Facility Long-Term Stewardship

Pre-Disposal Costs (first three elements)

Disposal Facility Costs (last four elements)

Section 3.1 discusses the first three, pre-disposal cost elements. Section 3.2 presents the analysis of the latter four, disposal facility related, elements. The total costs for different combinations of waste types and disposal sites are summarized in Section 4.1.

3.1 Pre-Disposal Costs: Waste Preparation, Packaging, and Transportation

Pre-disposal activities were evaluated for the three principal pre-disposal cost sub-elements: waste preparation, waste packaging, and transportation to the disposal facility. Figure 3.1 summarizes the pre-disposal cost element ranges for LLW disposed of at DOE facilities and at Envirocare. The DOE facilities include NTS, Hanford LLBG, Savannah River Site trenches, Hanford ERDF CERCLA disposal facility, and the Fernald OSDF CERCLA disposal facility. The blue bars indicate the approximate pre-disposal cost data spread for waste disposed of at DOE facilities. The bars in red are for waste disposed of at Envirocare. It should be noted that the high end of a cost range is frequently associated with a small or unusual waste volume that requires special handling.

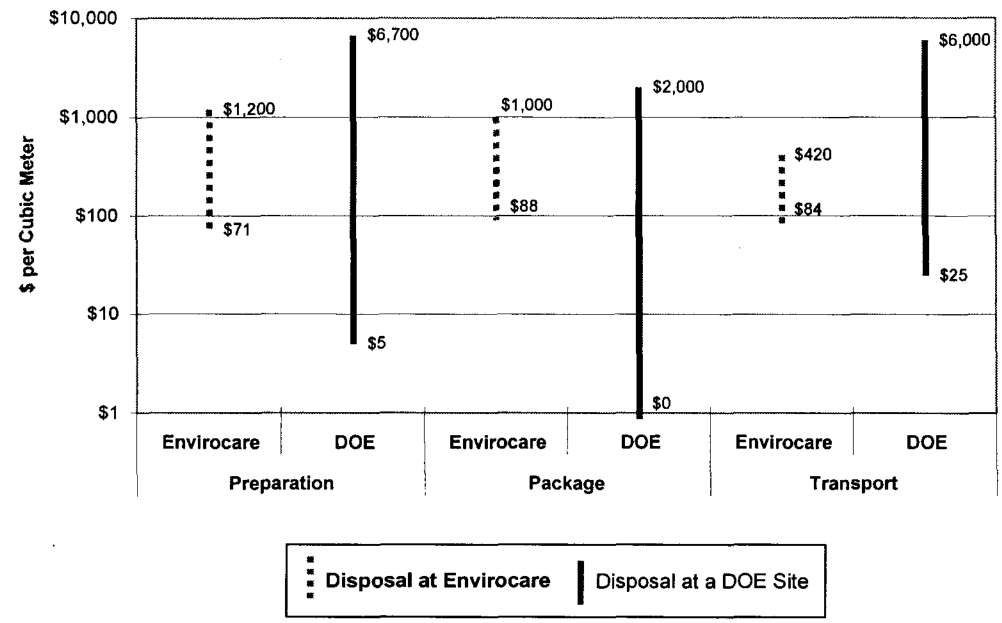
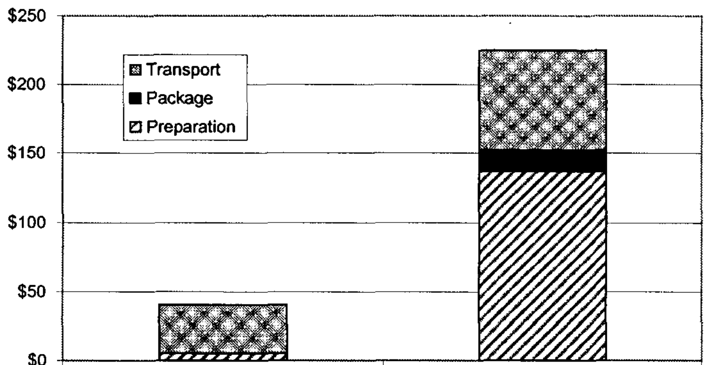


Figure 3.1. Comparison of Ranges of Pre-Disposal Costs for DOE and Commercial Disposal Facilities.
Source: Data provided by DOE site personnel at Chicago Operations Office, Femald Environmental Management Project, Hanford Site, Oak Ridge Reservation, Paducah, and Savannah River Site.

As illustrated in Figure 3.1, pre-disposal costs vary over a very wide range. The wide range is due to the choice of disposal facility, as well as the specific waste characteristics, pedigree of knowledge associated with the waste, treatment process used, and waste packaging needs. In addition, high unit costs result when fixed costs are amortized over small waste volumes, as may occur with small waste generators.

Pre-disposal costs for on-site CERCLA disposal cells are much lower than for other facilities, as illustrated in Figure 3.2. For example, for the Hanford ERDF CERCLA disposal facility, waste preparation costs $5/m^3, there is no packaging cost, and waste transportation costs $35/m^3, for a total pre-disposal cost of $40/m^3. The zero packaging cost results because there is no container other than the transport vehicle, and costs associated with loading and maintaining the vehicle are captured in the transport cost element. Pre-disposal costs associated with on-site CERCLA disposal are much lower than for other disposal facilities due to the low costs associated with bulk landfill disposal (CERCLA cells are the closest DOE parallel to Envirocare bulk disposal) as well as the very large waste volumes involved.



	Hanford	Fernald
Transport	$35	$73
Package	$0	$16
Preparation	$5	$137

Figure 3.2. Pre-Disposal Costs for DOE On-Site CERCLA Disposal Facilities. *Source: Data provided by DOE site personnel at the Fernald Environmental Management Project and the Hanford Site.*

It should be noted that while information was collected from waste generators in the categories of waste preparation (including characterization and treatment), waste packaging, and waste transportation to the disposal location, that the information reported for those categories may not be truly separated along those lines as these are not customary DOE project accounting categories. For example, where one contractor, such as the Oak Ridge management and integration (M&I) contractor, provides overall waste management services for several other Oak Ridge contractors, the M&I contractor may not be aware of characterization costs for a given waste quantity when those costs are incurred by another contractor and the other contractor would not report on packaging or transportation services provided after the M&I contractor had custody of the waste. Similarly, if a contractor sends waste to a commercial waste processor, costs can appear under treatment that include characterization, treatment, packaging, transportation, and potentially disposal since such costs are frequently bundled into commercial processing costs. In addition, characterization costs are frequently associated with packaging and treatment and can be grouped with such costs when reported by various contractors – there are not uniform established rules for collecting and reporting such costs. The authors separated costs to the extent it was reasonable to do so based upon information provided by the waste generators, however, it is not certain that all bundled costs were fully recognized and separated. The individual cost elements are discussed in more detail in Sections 3.1.1 through 3.1.3 below.

3.1.1 Waste Preparation

The cost to prepare waste for disposal consists of waste characterization costs and waste treatment costs. Waste characterization costs are associated with those work elements required to determine and certify that the waste properties (a) conform to the disposal site WAC requirements, (b) meet the waste generator site waste management and quality assurance protocols, and (c) comply with applicable DOE, waste generator, Department of Transportation, and disposal site regulatory requirements. Waste characterization activities may include waste sampling and analysis, Quality Assurance/Quality Control (QA/QC), auditing, waste certification and labeling, and pre-shipment notifications to the disposal site.

The cost and difficulty of waste characterization is generally less for on-site disposal than for off-site disposal, particularly for bulk disposal such as that in on-site CERCLA cells, because the vast majority of characterization required for CERCLA disposal is carried out during the Remedial Investigation/ Feasibility Study (RI/FS) process. Characterization costs can substantially increase if special handling or protocols are required as a result of such factors as suspected alpha emitters in the waste or high contact dose levels. Bulk wastes from CERCLA activities typically have been more recently characterized versus DOE's much older containerized waste. Much of this older waste was packaged during weapons production activities and its characteristics often were not sufficiently well documented to allow generators now to determine compliance with WAC without additional inspection and analyses.

Figure 3.3 depicts the range of characterization costs for disposal of off-site wastes at NTS, Hanford, and Envirocare. As illustrated in the figure, characterization costs can be higher for wastes shipped to NTS and Hanford for disposal than for wastes sent to Envirocare. The major factors that contribute to this are: (a) protocols associated with the ability to accept, handle, and dispose of higher activity wastes at NTS and Hanford; and (b) wastes shipped to NTS and Hanford for disposal being containerized rather than shipped in bulk,[34] i.e., there is more paperwork for many small containers than for one large container of equivalent volume.

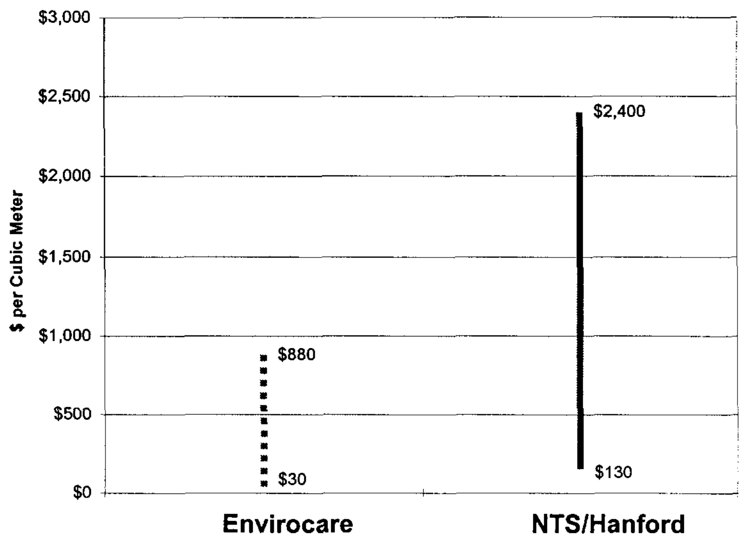


Figure 3.3. Characterization Costs for Off-Site LLW Disposal at NTS, Hanford, and Envirocare. *Source: Data provided by DOE site personnel at Chicago Operations Office, Oak Ridge Reservation, Paducah, Fernald, and Savannah River.*

As illustrated by Figure 3.3, the pre-disposal costs to meet NTS and Hanford waste acceptance program requirements range from $\$130/m^3$ to $\$2,400/m^3$, depending upon the type, volume, radioactive material concentrations, and complexity of the wastes. Characterization costs for LLW that DOE currently ships to Envirocare range from \$30 to $\$880/m^3$. Much of this difference between NTS/Hanford and Envirocare may be due to bulk shipments and low activity levels being the mainstay of Envirocare. In comparing

[34] In rare instances Hanford does perform bulk disposal.

costs between NTS and Hanford it should be noted that the volumes shipped to NTS are typically much greater than the volumes shipped to Hanford. Thus, costs to prepare waste for shipment to NTS are amortized over a large volume, whereas costs to prepare waste for shipment to Hanford are typically applied to a much smaller volume resulting in higher costs when measured on a unit cost basis. The high value shown in Figure 3.3 for NTS/Hanford represents characterization of a small quantity of waste for disposal at Hanford.

The waste disposal protocols at NTS and Hanford are configured to safely accept, handle, and dispose of the full range of LLW suitable for land disposal. NTS and Hanford have rigorous protocols consistent with the waste accepted for disposal (i.e., non-destructive examination, auditing, waste certification personnel, training, bar-coding). NTS requires that generators have an approved waste certification program and personnel independent of production that are approved by NTS annually to oversee the waste processing. Periodic audits of suppliers and processes are another key requirement for disposal at NTS. NTS also requires sampling and expert knowledge of the waste generation process to prove that the waste does not contain RCRA-regulated waste. Hanford relies on a combination of sampling, process knowledge, and waste verification (non-destructive examination with X-rays) at the disposal site. Waste sent to both sites undergoes radiological and hazardous sampling and characterization by the generators.

The NTS and Envirocare disposal facilities use significantly different QA processes for certifying a generator as an approved shipper and for ensuring that the generators comply with the facility's WAC. For illustrative purposes, some examples of differences between the characterization protocols used for NTS and those used by Envirocare are identified in Table 3.1. It should be borne in mind when reviewing these differences that they are primarily attributable to the significant differences in the waste activity levels accepted at those two sites. For example, Envirocare's website documents the more stringent "Containerized Class A Waste Acceptance Guidelines" and acceptance protocols for managing the higher-level containerized wastes that can now be accepted under their full Class A license. Conversely, despite graded approaches, DOE protocols tend to result in higher characterization costs to generators, even for very low activity wastes. These different approaches have schedule implications as well as cost implications, with the additional NTS requirements potentially creating a schedule delay. However, sites differed widely in their experiences relative to scheduling impacts for waste shipped to NTS.[35] During its review, YAHSGS was told by some waste generators that LLW sent to off-site DOE disposal facilities requires more characterization time and resources than LLW sent to Envirocare. Conversely, RFETS indicated that there are no identifiable pre-disposal cost differences between NTS and Envirocare disposal because RFETS has one integrated waste characterization program it uses regardless of where the waste goes.

NTS and Hanford also use different QA processes to verify that generators comply with the site WAC. The Hanford QA system uses verification to prove compliance; Hanford usually verifies waste (non-destructive examination using X-ray technology) when it is received at the Hanford site.[36] NTS prequalifies waste generators for its characterization protocols and then relies on generator characterizations and periodic QA audits at the waste generator facilities.[37] While Hanford verifies a significant portion of waste upon receipt, generator waste characterization programs are reported to be no less stringent than for NTS.[38]

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[35] Some sites stated the lead time involved to ship waste to NTS sometimes inclined them to ship to Envirocare; other sites pointed out that with good project planning, this becomes unimportant (i.e., it only becomes an issue with short lead-time shipments).

[36] Some waste is verified at the generator's facility.

[37] NTS and Hanford are currently working together to standardize the waste acceptance processes for the two sites. See, for example, Bechtel Nevada, "Nevada Test Site/Hanford Site Virtual Waste Acceptance Process," LLW-1300-003, September 2001.

[38] The DOE Chicago Operations Office reports that they maintain a stringent waste characterization program for waste shipments to Hanford because any potential for a question at Hanford during their verification can result in

Table 3.1. Comparison Between Selected NTS and Envirocare WAC and Characterization Requirements

Key NTS Disposal Facility WAC and Operational Requirements	Envirocare Counterpart
Waste burial at DOE sites under strict controls per DOE Order 435.1[39]	Permitted by state of Utah under NRC Agreement State protocols
Waste generator develops and maintains a Waste Certification Program Plan that is reviewed and approved periodically	Waste shipper develops profiles and then certifies that it is maintained within the profile
Periodic Audits (annual tabletop audit, site visit every 1 to 3 years based on performance)	Verification performed at disposal site. Envirocare conducts audits if problems occur
Waste shipments are authorized only after outstanding audit observations and findings are closed and corrective actions are validated based on objective evidence or a return site visit	Scheduling is generally straightforward for waste that meets generator profiles previously established. Establishing new profiles can be time consuming
Appointed and controlled Waste Certification Officer (WCO) and Waste Package Certifier (WPC) personnel who are independent of production and function as the QA/QC "eyes and ears" for NTS at the site. (At least two per site)	No corresponding requirement
WCO "hold points" required in waste handling, packaging, and shipping procedures	No corresponding requirement
Statistical Sampling (or process knowledge) to prove waste is not mixed waste	Similar requirement
Waste Profile Review and Approval goes through 3 levels: Prime Contractor (Bechtel-Nevada), DOE Office, state of Nevada. (Typical time frames are 3 to 9 mo.)	Envirocare approves the profile (Utah is notified)
Non-compliant wastes result in immediate "stop work" that requires additional audits and assessments by DOE before restart	Non-compliant issues documented by Envirocare and may be corrected on a timely basis, depending upon the issue
Accept 0.5-1 volume % free-liquids upon receipt (based on waste form)	Does not allow free liquids for bulk disposal. Treatment surcharges assessed for unacceptable moisture content
Accepts all LLW waste activity levels	Accepts contact-handled Class A wastes only under existing DOE contract
Reports only isotopes that exceed 1% of the total package activity	Reports all isotopes detected
Not required	Receipt verification, sampling, and analysis
Not required	Fingerprint analysis

considerable expense on the part of the generator to prove that the waste is compliant with the WAC. For example, an alleged detection of a prohibited item during Hanford real time radiography (RTR) verification often will result in return of the waste to the originating site, or the expense of having Hanford open the container and verify that the detection was false. In order to document what they are shipping, generators have installed their own RTR, hand sort the waste to ensure that prohibited item potential is minimized, videotape the waste sorting, and prepare detailed records of container contents.

[39] DOE is self-regulated for radioactive materials, deriving its authority from the Atomic Energy Act of 1954, as amended, the same legislative source of authority under which the Nuclear Regulatory Commission operates. DOE's self-regulation responsibilities require that it establish and operate within strict protocols consistent with its responsibility to protect the public health and safety, the environment, and its own workers. DOE's internal protocols tend to be substantially more rigorous than those used in competitive commercial market sectors. DOE site contractors that operate disposal facilities operate under DOE Order 435.1, the DOE Order governing waste management operations, and site-specific protocols that implement that Order.

Treatment (or conditioning) is generally not required for DOE LLW. For LLW disposed of at DOE sites, treatment would normally consist of encapsulating sealed sources in concrete before disposal or mixing sludges or liquids with grout or an absorbant to remove free water. It should be noted that if wastes are sent to a commercial company for treatment, the ability to distinguish between treatment, packaging, and transportation is lost due to commercial pricing practices.

3.1.2 Waste Packaging

Waste packaging must be considered in an evaluation of waste disposal costs, because the disposal site WAC can influence the need, type, and pedigree of waste packaging. All waste[40] sent to NTS and Hanford[41] for disposal must be disposed of in approved containers.[42] Other than some CERCLA waste, this is typical of DOE disposal sites and of the commercial disposal sites in Barnwell, SC, and Richland, WA. Conversely, Envirocare's permits and licenses allow the disposal of some low-activity LLW in bulk form without packaging. If the same waste were to be disposed of in containers, a higher disposal fee would be assessed.[43] Envirocare also accepts LLW in reusable containers such as roll-off boxes and inter-modal containers. These reusable containers can be returned to the waste generator; however, additional charges are incurred for decontaminating and returning containers that may off-set recycle related savings.[44]

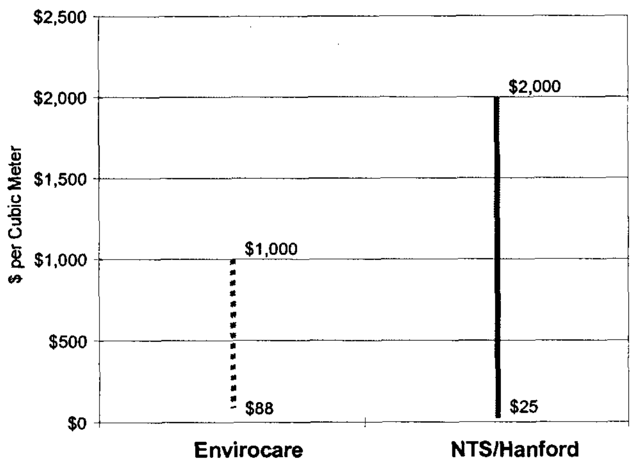

Figure 3.4. Packaging Costs for Off-Site LLW Disposal at NTS, Hanford, and Envirocare. *Source: Data provided by DOE site personnel at Chicago Operations Office, Oak Ridge Reservation, Paducah, Fernald, and Savannah River.*

Note: DOE costs illustrated are for contact-handled waste. Costs for packaging for remote-handled wastes are substantially higher, e.g., greater than $45,000/m^3.

Packaging costs include the cost of the containers; the cost of placing wastes into the containers; and the cost of labeling the containers. The latter two cost elements may cost more than the cost of the container. Figure 3.4 illustrates the range of waste packaging costs to prepare LLW for disposal at NTS, Hanford,

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40 In rare instances, Hanford does perform bulk disposal.
41 This does not apply to Hanford CERCLA waste that originates at the Hanford site.
42 The terms "package" and "container" are used interchangeably.
43 All disposal sites charge for the volume of waste disposed. Accordingly, waste disposed of in containers (drums, boxes) can incur a greater volume charge than waste disposed of in bulk because of the difference between the waste volume and the exterior volume of the container (disposal charges are based on the volume and bulk disposal produces a smaller disposal volume).
44 Brookhaven National Laboratory experience with return of containers indicates that it is not cost-effective because containers are often damaged during the handling and unloading process.

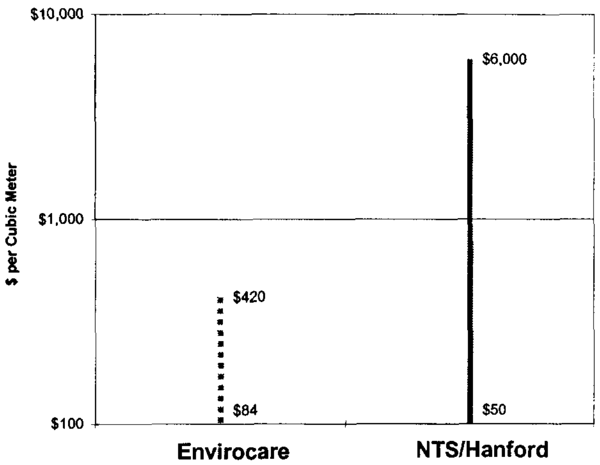
and Envirocare. The lower waste packaging costs for disposal at Envirocare relative to those at NTS and Hanford reflect the fact that most waste shipped to Envirocare is shipped in bulk containers whereas waste shipped to NTS and Hanford may be packaged in a variety of smaller containers.[45] The figure may not reflect the full range of packaging costs because in some cases costs for waste packaging are captured under waste preparation or transportation (e.g., when using a commercial company for treatment). Note also that legacy waste may already have been packaged.[46] Furthermore, the figure depicts costs for packaging of contact-handled LLW; costs for packaging of remote-handled LLW may be substantially greater than those depicted in the figure.

3.1.3 Waste Transportation

Waste transportation costs are primarily a function of distance, the mode of transportation (truck or rail), and the waste characteristics. For DOE waste generators east of Utah that require off-site disposal, Envirocare provides a transportation distance advantage. The cost of transportation per unit of waste is largely dependent upon the waste density, including waste packaging. Metal containers increase the transportation costs because a portion of the payload (on the order of 25%) typically is required for the package weight. For example, soils shipped in intermodal containers by truck will typically constitute approximately 30,000 pounds out of the 40,000-pound target payload because of the tare weight of the intermodal containers. A rail car provides approximately five times the payload of a legal weight truck and can provide substantial cost advantages when rail transportation is available to both the generator and the disposal site. Envirocare has rail access, NTS does not, and Hanford will in the future but does not at the time of this report.[47] Figure 3.5 provides transportation cost information for wastes sent from various DOE sites to NTS, Hanford, and Envirocare for disposal.

Hanford and NTS currently accept waste shipments by truck. Hanford has also received waste via intermodal shipments,[48] and Hanford has access to barge usage through the adjacent Port of Benton. Envirocare accepts waste by truck or rail (e.g., Fernald has access to rail and uses rail for shipments to Envirocare). For long-hauls, sites that lack rail access can sometimes use a combination of rail and trucking via inter-modal containers that move from flatbed trucks to rail cars and visa versa. If the waste generator does not have rail access, then the generator must find a means to transload the intermodal containers from trucks to rail reasonably close to the generator's site to realize the cost advantages of rail. For wastes shipped by rail to NTS, a means of transfer and loading (transloading) would need to be established near the disposal end of the route to make intermodal shipments cost effective. Transportation for on-site disposal is handled by truck. Shipments by truck cost approximately \$0.15 to \$0.30 per m^3/mile (net waste volume excluding the package), depending upon the packaging method and waste density. Shipment by rail costs approximately \$0.08 to \$0.20 per m^3/mile (net waste volume excluding the package), depending upon the packaging method/efficiency and routing.[49]

[45] If the waste is already containerized (e.g., legacy waste already in containers), then disposal at NTS may be a more economical alternative to disposal at Envirocare due to the cost of emptying containers and the fact that the empty containers would be a radioactive waste itself.
[46] The legacy waste packages would typically be opened to determine/confirm the content – a characterization cost.
[47] Hanford is presently re-establishing their rail system.
[48] Hanford received intermodal shipments from Parks Township. The waste was shipped by rail to the site, then off-loaded and trucked to the burial grounds.
[49] Rail tariffs vary with the rail ownership such that some short hauls can invoke high tariffs that cause disproportionately high costs per mile.



Note: The high values for NTS and Hanford are for shipment of small quantities of higher-activity wastes. The average cost of transportation is substantially less than the high value shown.

Figure 3.5. Transportation Costs for Off-Site LLW Disposal at NTS, Hanford, and Envirocare.
Source: Data provided by DOE site personnel at Chicago Operations Office, Oak Ridge Reservation, Paducah, Fernald, and Savannah River.

3.2 Disposal Facility Costs

Table 3.2 summarizes the life cycle costs for disposal at DOE and commercial facilities. Facilities differ greatly in the types of waste they can accept: DOE's CERCLA facilities dispose of lower-activity wastes, while DOE's other facilities are "full-service" LLW disposal providers. To illustrate this difference, DOE disposal facilities are presented in two categories in the table.

Per DOE direction, for DOE disposal facilities, the unit life cycle cost reported in Table 3.2 was calculated as the present value of future costs divided by the total waste volume disposed of in the facility. For commercial facilities, the commercial price for disposal is presented. The calculations for DOE facilities include all future construction, operation, closure, and long-term stewardship costs for the disposal facility from FY 2002 forward and reflect all planned future waste disposal from FY 2002 forward. The details of the calculations are provided in the spreadsheets in Appendix B.

Table 3.2. Life Cycle Costs for Disposal of DOE LLW at Various Facilities

Disposal Site	Life Cycle Cost ($/m3)
DOE CERCLA Disposal Facilities:	
Hanford ERDF	$29
Oak Ridge EMWMF	$140
INEEL ICDF	$160
Fernald OSDF	$190
DOE Non-CERCLA Disposal Facilities:	
Savannah River Site Trenches	$130
Nevada Test Site	$320
INEEL RWMC	$700
Hanford LLBG	$2,000
Savannah River Site Vaults	$2,100
Commercial Disposal Facilities:	
Envirocare (soil)	$180
Envirocare (debris)	$520
Barnwell	$14,000
US Ecology	$2,500

Notes: (1) To gain a true cost comparison of disposal sites, generator costs including waste preparation, packaging, and transportation must also be considered, as these vary depending on the disposal site. (2) These costs do not include surcharges for remote handling, shielding, MLLW, etc.(3) The values shown for Barnwell and US Ecology are their nominal average prices for LLW and do not include curie or dose rate surcharges. (4) Cost estimates for DOE facilities include all future closure and long-term stewardship costs even though, for many of the facilities, these are partially sunk costs that DOE must pay regardless of whether any future waste is emplaced in the facility.

The Barnwell Waste Management Facility is the most expensive of the disposal sites primarily because of high state taxes placed on disposal. Of the DOE facilities, SRS vaults and Hanford LLBG have the highest costs. The high cost of disposal at the SRS vaults results from the large capital cost of constructing the vaults. Only waste that requires vault construction is placed in the vaults. The vaults are used for waste that is high in radionuclide content and/or too large to ship in available transportation containers. SRS uses performance assessment to determine waste requirements for disposal. In general, waste that is low in radionuclide content is disposed of in a trench (some waste is also shipped off-site for disposal); high-activity waste goes into the vaults. The vaults also contain large pieces of equipment for which it is not economical to transport for off-site disposal (e.g., large vessels, ion exchange columns, and evaporator pots).

The high cost of the Hanford LLBG results from the high activity of the waste, the acceptance of small quantities of waste, closure costs related to previously disposed waste, and fixed costs of the facility. By including all future costs associated with the Hanford burial grounds, a large cost to close the entire acreage of the burial grounds is included. Approximately 90% of this closure cost is related to past waste emplacements, not the waste that is projected to be emplaced from FY 2002 forward. Thus, the Hanford LLBG cost estimate includes a large sunk cost that DOE must pay regardless of whether any future waste is emplaced in the burial grounds. Figure 3.6 illustrates that the majority of the life cycle disposal cost for the Hanford LLBG is due to fixed costs, capping of previously disposed waste, and long-term surveillance and maintenance.

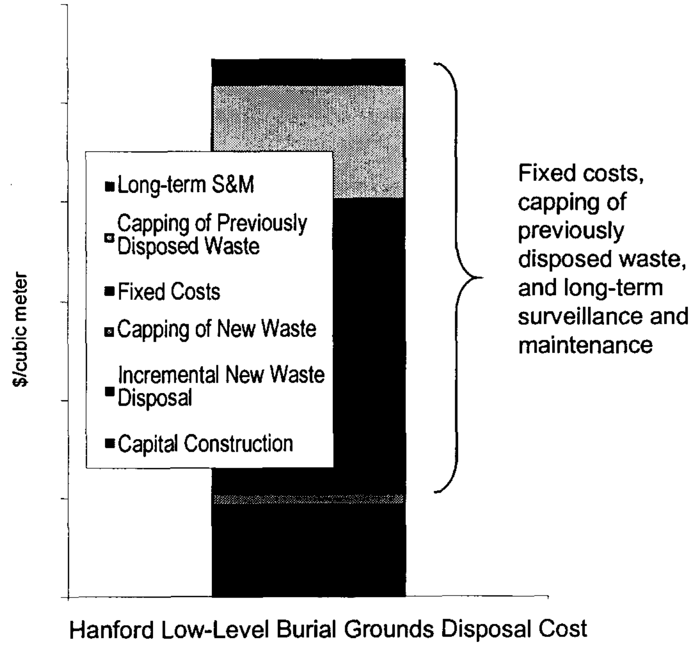


Figure 3.6. The Majority of the Disposal Cost for the Hanford Low-Level Burial Grounds is Due To Fixed Costs, Capping of Previously Disposed Waste, and Long-Term Surveillance and Maintenance.

The low cost of disposal at the Hanford ERDF CERCLA disposal facility results from the large waste volumes projected to be disposed of in that facility. To date, 1.5 million m^3 have been disposed of, and an additional 7.5 million m^3 are projected to be disposed of through FY 2042.

As discussed in Section 3.1, Envirocare differs from NTS in that Envirocare disposes of bulk waste whereas NTS disposes of containerized waste. Since Envirocare charges for disposal based on the waste volume rather than the outside volume of the container, this could make Envirocare even more favorable when compared with NTS than indicated in Table 3.2 for specific waste streams. Moreover, information received from Envirocare indicated that waste was frequently received in partially filled boxes[50] which, if also true for waste received at the DOE sites, could further favor Envirocare's costs. Such waste volume considerations should be factored in when making decisions on any waste stream and disposal facility.

Sections 3.2.1 through 3.2.4 discuss DOE on-site CERCLA disposal facilities. Sections 3.2.5 through 3.2.8 discuss non-CERCLA facilities for LLW disposal. Sections 3.2.9 through 3.2.11 discuss commercial disposal facilities.

3.2.1 Hanford Environmental Restoration Disposal Facility

The Environmental Restoration Disposal Facility (ERDF) is the heart of a major part of cleanup operations at the Hanford Site. It is a disposal facility for the contaminated soil and materials that are being excavated at the sites along the Columbia River. Construction of the first two cells began in May 1995, and the first shipment of waste was received on July 1, 1996. Each cell is 152 meters (500 feet) wide at the bottom, 21 meters (70 feet) deep, and over 304 meters (1,000 feet) wide at the surface. ERDF's liner is a system composed of multiple barriers, forming a primary and secondary protection system. Each system is designed to contain and collect moisture to prevent migration of contaminants to the soil and groundwater. Once ERDF is filled with waste, an engineered barrier will be placed on top to

[50] This information is not *de facto* proof that this is a wide-spread practice and, therefore, was not used in the analyses. Both the Hanford and NTS waste acceptance criteria specify that the void space in containers is to be minimal (Hanford WAC 3.5.6, NTS WAC 3.2.7), however, data regarding the actual void space in waste buried was not provided. Disposal sites generally strive to minimize void space to protect against post-closure subsidence.

prevent the release of waste and infiltration of rain. Currently, ERDF receives about 3,000 tons per day, and is expected to receive about 7 million tons of waste in the overall Hanford cleanup. Currently, ERDF holds between 2 and 3 million tons. ERDF receives only waste that is being cleaned up at Hanford CERCLA sites.[51]

Hanford has been operating the ERDF for disposal of on-site CERCLA waste since 1996 and, through FY 2001, has disposed of 1.5 million m^3 of waste at a total cost of $117 million. An additional 7.5 million m^3 are projected to be disposed of from FY 2002 through FY 2042. Disposal operations are projected to continue through FY 2042, followed by final closure and 100 years of long-term stewardship. ERDF is constructed in cell increments; additional cells are added as needed. As portions of the facility are filled, a cap is installed, so closure costs are incurred incrementally throughout the life of the facility.

3.2.2 Oak Ridge Environmental Management Waste Management Facility

The Oak Ridge on-site CERCLA disposal facility, the Environmental Management Waste Management Facility (EMWMF), is scheduled to begin operation in FY 2002. The EMWMF will accept waste from Oak Ridge Reservation CERCLA remedial actions only. The waste will consist primarily of soil and debris as LLW, MLLW, and hazardous waste. Sources of debris are expected to be building decontamination and decommissioning at the East Tennessee Technology Park (ETTP), and building and reactor D&D at Oak Ridge National Laboratory (ORNL). Approximately 30% of the wastes at the Oak Ridge Reservation are expected to require treatment to immobilize hazardous contaminants in soil and debris waste streams and to remove liquids from sludge waste streams to meet land disposal restrictions. Wastes may be delivered to the facility unpackaged in lined dump trucks, in roll-off boxes, or in sacrificial containers (drums or B-25 boxes).[52] A total of 1.3 million m^3 is projected to be disposed of in the facility.

The EMWMF is being built in increments of 400,000 yd^3. After each 400,000-yd^3cell is filled, a cap will be placed over it; after all cells are completed, one large contiguous cap will be installed to cover everything. Plans call for EMWMF to operate through FY 2010. Closure is projected to begin in FY 2005, when the first 400,000–yd^3cell will be filled. Per agreement with the state of Tennessee, long-term stewardship costs will be funded early in the program, with the funds placed into a Perpetual Care Fund that will be managed by the state.

3.2.3 INEEL CERCLA Disposal Facility

INEEL is building an on-site CERCLA disposal facility, the INEEL CERCLA Disposal Facility (ICDF). This facility will be located at the Idaho Nuclear Technology and Engineering Center, which, for CERCLA purposes, is designated as Waste Area Group (WAG) 3. The ICDF is located within the WAG 3 Area of Contamination, as defined by the OU 3-13 Record of Decision, and, as such, a significant amount of soil and debris waste from WAG 3 would not require metals stabilization treatment to meet RCRA Land Disposal Restrictions before disposal.[53] ICDF would also accept INEEL CERCLA waste from outside WAG 3. That waste may require metals stabilization treatment if necessary to comply with

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[51] Source: http://www.hanford.gov/tours/erdf.html

[52] U.S. Department of Energy, "Profiles of Environmental Restoration CERCLA Disposal Facilities," DOE/EM-0387, July 1999.

[53] Over 30% of the waste targeted for the ICDF would otherwise be called "mixed waste" and require metals stabilization treatment to meet RCRA Land Disposal Restrictions. However, the CERCLA RI/FS process has identified acceptable site-specific treatment levels without stabilization that are much more cost-effective and still protective of the public health and the environment.

RCRA Land Disposal Restrictions. Based on current projections, about 28% of the ICDF waste will come from sources outside WAG 3.

The ICDF is projected to begin operation in FY 2003. The plan is for the facility to operate through FY 2012, followed by closure and 100 years of long-term stewardship. A total of 320,000 m^3 is projected to be disposed of in the facility. In October 2001, INEEL completed a cost analysis of on-site disposal at the ICDF.[54] The cost analysis was based on 30% design completion, but during a recent site visit INEEL personnel stated that they are now at the 90% design stage and the numbers in the analysis have not changed. This study used the data from the October 2001 analysis.

3.2.4 Fernald On-Site Disposal Facility

The Fernald On-Site Disposal Facility (OSDF) is located on the east side of the former production area at the 1,050-acre Fernald site. The footprint to be used for waste disposal is approximately 70 acres, with a total facility area of 140 acres including the buffer zone. The OSDF receives LLW, primarily as soils with some debris. The facility will receive waste from Fernald only. The WAC were developed to protect the underlying Great Miami Aquifer and include maximum concentration limits on specific radionuclides and chemicals, size criteria, and a list of prohibited items.[55] Waste not meeting the WAC for the OSDF is sent off-site to NTS and Envirocare. Fernald has found bulk shipments to Envirocare to be cost-effective, mainly because shipments are sent by rail.

The Fernald OSDF began operation in FY 1998 and has disposed of 510,000 m^3 of waste through FY 2001. An additional 1.4 million m^3 are projected to be disposed of from FY 2002 through FY 2006. Disposal operations are projected to continue through FY 2006, followed by closure and 100 years of long-term stewardship.

3.2.5 Savannah River Site Vaults and Trenches

Savannah River Site (SRS) disposes of LLW on site in either slit trenches (lower activity waste, mainly soil and debris), engineered trenches (higher isotopic concentrations), or vaults (still higher activities and large equipment). Some LLW is also sent off site to NTS and Envirocare. From FY 2002 through FY 2026, 27,000 m^3 of LLW are projected to be disposed of in the vaults and 140,000 $m^3$are projected to be disposed of in the trenches.

SRS does not plan to close LLW disposal facilities for many decades. However, beyond FY 2026 plans and projected waste quantities are highly speculative. Therefore, for the purposes of this analysis, YAHSGS assumed cessation of disposal operations in FY 2026, followed by closure and long-term stewardship.

3.2.6 Nevada Test Site Radioactive Waste Management Sites

Currently, LLW is disposed of in engineered pits and trenches and in subsidence craters at two Radioactive Waste Management Sites on the NTS. LLW disposed of at the NTS can only be accepted from approved DOE and U.S. Department of Defense generators. Projected future waste disposal volumes range from 2 thousand to almost 90 thousand m^3 of LLW per year. From 1978 until the present, the

[54] U.S. Department of Energy, "On-Site Versus Off-Site Soil and Debris Disposal Comparison for the ICDF Complex," October 2001.
[55] U.S. Department of Energy, "Profiles of Environmental Restoration CERCLA Disposal Facilities," DOE/EM-0387, July 1999.

Area 3 and Area 5 Radioactive Waste Management Sites at the NTS have received over 590,000 m^3 of LLW for disposal.[56] Looking forward, 570,000 m^3 of waste are projected to be disposed of between FY 2002 and FY 2021. Disposal at NTS may not end in FY 2021; however, waste volumes after that time are unknown.

Both NTS LLW and LLW from across the complex is disposed of at NTS.[57] Much of the waste disposed of at NTS is higher-activity waste that does not meet the Envirocare WAC. Hence, regardless of any potential decisions that may be made to dispose of lower-activity wastes at commercial facilities, NTS will continue to have an important disposal mission that will keep the disposal site open and operating. Life cycle costs are estimated for the NTS disposal facility for operations through FY 2021 and include closure and 100 years of long-term stewardship.

3.2.7 INEEL Radioactive Waste Management Complex

INEEL operates a LLW disposal facility as part of the larger Radioactive Waste Management Complex (RWMC) for disposal of both contact-handled and remote-handled LLW. The LLW facility is planned to continue operation until FY 2020, at which time it will be closed. Beyond that time, INEEL will solely use off-site LLW disposal. Current projections indicate that contact-handled LLW would go to either NTS, Hanford, or Envirocare and remote-handled LLW would go to Hanford. Approximately 30,000 m^3 of waste have been disposed of in the LLW disposal facility, and an additional 48,000 m^3 are projected to be emplaced from FY 2002 through FY 2020.

The remote-handled waste streams currently being disposed at the RWMC have no alternative disposition paths available at this time. The design, fabrication, and licensing of an NRC-certified cask to perform off-site remote-handled LLW disposal is anticipated to cost in excess of $10 million and take 12-15 years to complete. This estimate does not include the facility modifications or annual operating expenses to perform this new operation. Because of the absence of an off-site transportation option for INEEL's remote-handled LLW, this waste is being disposed of on-site. While this remote-handled LLW represents approximately 5% of the waste volume, it constitutes approximately 50% of the disposal facility cost.[58]

3.2.8 Hanford Low-Level Burial Grounds

The LLBG at the Hanford Site are used for disposal of LLW from the Hanford Site and off-site generators. Six LLBGs are located in the 200 West Area, and two in the 200 East Area.[59] Almost 700,000 m^3 of waste have already been disposed of, and 75,000 m^3 are projected to be disposed of between FY 2002 and FY 2026.

Hanford does not have specific plans to close the LLW disposal facility in FY 2026. However, beyond that date, plans and projected waste quantities are highly speculative. Therefore, for the purposes of this analysis, disposal operations were assumed to stop in FY 2026, followed by closure and long-term stewardship. The life cycle cost of the Hanford LLBG encompasses all LLW streams and LLW waste classes, both contact-handled and remote-handled.

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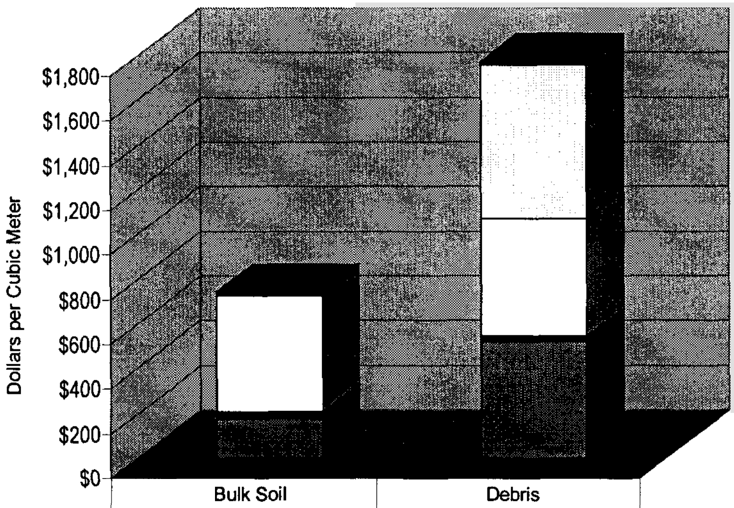
[56] U.S. Department of Energy, Nevada Operations Office, Waste Management Division, Low-Level Waste Project, http://www.nv.doe.gov/programs/envmgmt/blackmtn/WMLow-levelWasteProject.htm
[57] NTS also disposes of classified waste. DOE classified waste cannot be disposed of in a commercial facility.
[58] Source: Personal communication from Robert Stump, March 12, 2002.
[59] U.S. Department of Energy, Richland Operations Office, Waste Management Division Fact Sheet. http://www.hanford.gov/wastemgt/doe/files/Waste_Management_Fact_Sheet_FINAL.pdf

3.2.9 Envirocare of Utah, Inc.

Envirocare of Utah, Inc., is a commercial radioactive waste disposal facility located 80 miles west of Salt Lake City in western Tooele County. The facility began operation in 1988. The site is located on an ancient lake bed just west of the Cedar Mountains. Land surrounding Envirocare is sparsely grazed open range land. Radioactive wastes are disposed of by modified shallow land burial. Envirocare practices "cap-as-you-go" closure, and the state of Utah requires Envirocare to carry a "surety fund" for eventual site closure and long-term stewardship. This "surety fund" is currently at $30 million.

Envirocare is licensed by the Division of Radiation Control to dispose of naturally occurring radioactive materials and Class A LLW. Envirocare is not currently allowed to accept Class B and C LLW. Since 1996, Envirocare has treated and buried nearly 1 million m^3 of DOE LLW and MLLW, and this volume represents over half of their total waste buried. Envirocare has established a number of contracts with private and government entities to accept waste for disposal. At this time, DOE does not have a contract for the disposal of higher-activity Class A waste at Envirocare.

Envirocare's contracts with DOE contain various clauses and exceptions, but the lowest rate per the present DOE-Ohio contract for disposal of contaminated soil is $\$184/m^3$; for debris[60] the lowest rate is $\$519/m^3$. These rates may be higher based on modes of transport, oversize debris, and container types. For example, drums shipped by truck cost more. Envirocare's multi-tiered pricing structure is illustrated in Figure 3.7. Prices escalate as the waste particle size increases from soil to debris to oversized debris (over 10 inches), as well as for excess moisture in the waste. Surcharges are imposed for cleaning trucks or railcars, as appropriate, for release from the site. Similar surcharges are imposed to clean and release containers that were not used for disposal (i.e., waste is emptied from the containers onto the ground for the bulk disposal areas).



	Bulk Soil	Debris
■ Container Cleaning	$16	$16
□ Oversize Treatment Surcharge	$0	$690
□ Moisture Treatment Surcharge	$520	$520
■ Cleaning Trucks/Railcars (Average)	$27	$27
▩ Disposal Charge	$180	$520

Figure 3.7. Envirocare Pricing Approach for DOE Low-Level Waste. *Source: DE-AM24-98OH20053, DOE Ohio Field Office LLW Disposal Contract with Envirocare of Utah, Inc.*

[60] While debris is charged at a higher rate than bulk soil containing up to 10% debris, DOE sites do dispose of debris at the bulk soil rate by coordinating arrival of debris shipments with soil shipments from Fernald or other sites. This has been particularly effective for Brookhaven National Laboratory.

Current contract rates can be changed when new disposal contracts, or modifications, are negotiated (the current DOE LLW disposal contract expires June 29, 2004 but has 4 additional option years) making it speculative to predict long-term future rates. In addition, new contracts and revisions may require that additional taxes be included. New Utah legislation imposes a state tax on waste disposal that will be charged to DOE at some time in the future.[61] Whether the new taxes will be imposed when option years are exercised, when contract modifications are negotiated, or when new contracts are put into place is uncertain. It should be noted that contract prices will have to be renegotiated upon expiration of the current contract and the follow-on prices will most likely be based on the market conditions at that time.

3.2.10 Barnwell Waste Management Facility

Chem-Nuclear Systems, L.L.C. operates a LLW disposal facility in Barnwell, South Carolina. The 235-acre facility occupies property owned by the state of South Carolina and leased to Chem-Nuclear Systems. The Barnwell Waste Management Facility operates under the authority of Radioactive Material License 097 issued by the South Carolina Department of Health and Environmental Control.

Since the disposal facility began operation in 1971, about 28 million ft^3 or 90% of the available disposal volume has been used. The Barnwell site is the most expensive of the commercial disposal sites primarily because of high state taxes placed on disposal. Barnwell accepts Class A, B, and C LLW and does not accept MLLW. Although the site historically accepted waste from any location, South Carolina recently formed the Atlantic Compact with the states of Connecticut and New Jersey and is phasing out waste from outside that compact over time. The nominal disposal price assumed for Barnwell is $14,000/$m^3$ ($400/$ft^3$), which is not competitive for DOE waste.

3.2.11 US Ecology, Richland, WA

The state of Washington's commercial LLW disposal site has accepted waste since 1965 on a 100-acre tract within the DOE's Hanford Site. The land is leased to the state and subleased to US Ecology Inc. The site operates under radioactive materials licenses issued by the Department of Health and the Nuclear Regulatory Commission. Since 1993, it has been the regional commercial LLW disposal site for 11 western states. To date, the site has taken in about 13.5 million ft^3 of waste.

US Ecology Inc. operates the disposal facility, which accepts Class A, B, and C LLW and naturally occurring and accelerator-produced radioactive material but does not accept MLLW. The majority of the waste is buried in steel boxes or drums. Liquid waste must be solidified. All waste containers are placed in trenches that are typically 45 feet deep, 1,000 feet long, and 150 feet wide. All radioactive waste shipments are inspected by the Department of Health's on-site inspector before disposal is allowed. After a trench is filled with waste, it is covered with at least 8 feet of soil and 6 inches of gravel.

The disposal site serves the Northwest Compact[62] but can receive waste from the Rocky Mountain Compact, other than DOE waste, if the waste is released for disposal by the Rocky Mountain Compact. The nominal disposal price for contact-handled Class A waste is approximately $2500/$m^3$, based upon a number of sub-rate elements that typically work out to approximately that value.

[61] In February 2001 Utah passed new legislation that would impose a gross receipts tax ranging from 5% to 12% on Envirocare, depending on what type of waste is accepted. It also calls for an annual payment of $400,000 starting in 2002.

[62] Both Hanford and INEEL are located in states in the Northwest Compact.

4.0 Conclusions and Discussion

4.1 Life Cycle Cost Summary

Figure 4.1 summarizes the results of the analysis, expressed in cost per cubic meter of waste for each disposal facility. The bottom solid bar in Figure 4.1 represents the disposal facility cost. For Envirocare, the bottom solid bar represents the Envirocare price for disposal. Per DOE direction, the unit cost of DOE disposal facilities was calculated as the present value of future costs divided by the total waste volume to be disposed of in the facility. The calculations for DOE facilities include all future construction, operation, closure, and long-term stewardship costs for the disposal facilities from FY2002 forward and reflect all planned future waste disposal from FY2002 forward. The cross-hatched upper bars in Figure 4.1 represent the midpoint in the range of costs for preparing, packaging, and transporting waste to the disposal facility (i.e., pre-disposal costs borne by DOE waste generator sites). The full range of pre-disposal costs associated with each facility is represented by a vertical line to the left of the stacked bars. The total cost of waste disposal for a given waste stream is the sum of its waste-stream-specific pre-disposal costs (waste preparation, packaging, and transportation) and the disposal facility costs (which include construction, operation, closure, and long-term stewardship).

As indicated, the costs that precede but are necessary to disposal (i.e., waste preparation, packaging, and transportation) can be significantly greater than the costs at the disposal facility. High pre-disposal costs are normally associated with the more complex, higher radioactivity wastes such as those disposed of at NTS and Hanford, as well as certain LLW that requires stabilization before disposal. As illustrated, costs for DOE non-CERCLA on-site and off-site disposal facilities exceed those for on-site CERCLA disposal and some types of waste disposed at Envirocare. However much of the waste disposed of in the non-CERCLA on-site disposal facilities, NTS, and Hanford would not meet the current waste acceptance criteria of the CERCLA disposal facilities and commercial options and thus is not currently eligible for disposal in those facilities.

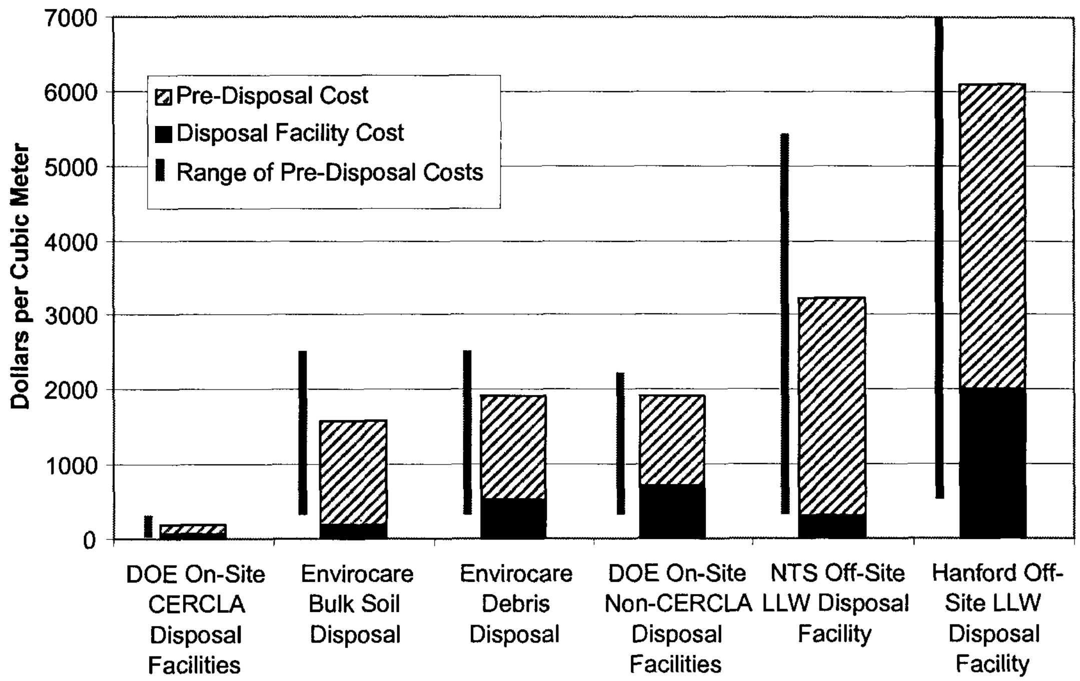
In reviewing the preceding information, four considerations should be borne in mind.

1. DOE has hundreds of waste streams, each presenting potentially unique challenges that may lead to costs different from the values presented here.

2. Substantial differences occur from project to project regarding the manner in which seemingly similar types of costs are accounted for. This includes such things as which quality related efforts and documentation belong in characterization and which belong in waste packaging and whether broader project management costs should be allocated to the pre-disposal cost activities evaluated in this study. Furthermore, it should be noted that if wastes are sent to a commercial company for treatment, the ability to distinguish between treatment, packaging, and transportation costs is lost due to commercial pricing practices. The result is that the analyses and graphs presented provide a general indication of the overall magnitude of costs based upon the activities that occurred over the time frames that the data represent.

3. These costs represent a snapshot in time. Some costs will decrease as experience is gained; others may increase or decrease as cleanup projects enter new phases or encounter unanticipated waste or regulatory situations.

4. As illustrated in Figure 3.6, part of the life cycle disposal cost for DOE facilities is due to fixed costs, capping of previously disposed waste, and long-term surveillance and maintenance.



Disposal ($\$/m^3$)	68	180	520	710	320	2,000
Pre-Disposal ($\$/m^3$)	130	1,400	1,400	1,200	2,900	4,100
Total ($\$/m^3$)	200	1,600	1,900	1,900	3,200	6,100

Notes:

1. The pre-disposal cost indicated is the mid-point value in the range. Pre-disposal cost data used for this study did not include every waste stream and did not support calculation of a weighted average value for all DOE waste streams
2. The higher pre-disposal costs indicated are due to smaller waste quantities and/or higher-activity wastes.
3. Pre-disposal costs do not reflect costs for remote-handled LLW. Costs for off-site disposal of remote-handled LLW may be much higher than indicated here.
4. For DOE on-site CERCLA disposal facilities, the pre-disposal cost range indicates the range of costs for the two operating CERCLA disposal facilities: Hanford ERDF and Fernald OSDF (the Oak Ridge and INEEL CERCLA disposal facilities are not yet operating). The disposal facility cost is the weighted average cost of the four CERCLA disposal facilities: ERDF, OSDF, EMWMF, and ICDF.
5. For DOE on-site non-CERCLA LLW disposal, the pre-disposal cost range indicates the range of costs reported for the SRS trenches and the Hanford Low-Level Burial Grounds. The disposal facility cost is the weighted average cost of the five facilities used for on-site non-CERLCA LLW disposal: SRS trenches, SRS vaults, INEEL RWMC, NTS (on-site generated LLW), and Hanford LLBG (on-site generated LLW).
6. For DOE off-site LLW disposal at NTS, the pre-disposal cost range indicates the range of costs reported for LLW shipped to NTS from Oak Ridge Reservation, Fernald, and Paducah. The disposal facility cost is the cost of the NTS LLW disposal facility.
7. For DOE off-site LLW disposal at Hanford, the pre-disposal cost range indicates the range of costs reported for LLW shipped to Hanford from ETEC and the Chicago Operations Office. The disposal facility cost is the cost of the Hanford Low-Level Burial Grounds.

Figure 4.1. Costs of LLW Disposal Including Pre-Disposal Costs of Waste Preparation, Packaging, and Transportation, and Disposal Facility Costs Including Construction, Operation, Closure, and Long-Term Stewardship.

4.2 Conclusions and Discussion

This report compares the total cost to the government for disposal of DOE LLW at various DOE-owned and commercial disposal facilities. The following observations are made.

1. In gathering information for this study from DOE waste generators and DOE and commercial disposal sites, significant site-to-site protocol differences were apparent relative to data collection and reporting. Comparison of pre-disposal costs for different sites and wastes may not be constructive at present due to these disparities. If DOE is to use life cycle cost metrics to guide disposal site decisions, standardized protocols should be established to improve the bases for such decisions and for any subsequent audits or analyses.

2. Pre-disposal costs represent significant life cycle cost savings opportunities. Pre-disposal costs are the major cost component for all six waste disposal categories identified in Figure 4.1. Unit pre-disposal costs are strongly influenced by the radioactive constituents in the waste, the physical form of the waste, the origin of the waste, its point of generation relative to its disposal destination, and the volume of waste.[63] These factors result in substantial pre-disposal cost ranges for each disposal category listed.[64] Pre-disposal cost savings could be best realized by (a) developing a common pre-disposal cost chart of accounts for use by all waste generators, (b) reevaluating site generator pre-disposal costs on a common basis, and (c) establishing contractor incentives to reduce pre-disposal costs.

3. DOE's on-site CERCLA disposal cells represent the lowest cost option for waste that is eligible to be disposed of in those cells.

4. Commercial LLW and MLLW disposal services play a valuable and integral role in DOE's national cleanup strategy. With the exception of on-site disposal of CERCLA waste where available, commercial disposal services favorably compete with DOE's disposal options for bulk wastes with low concentrations of radionuclides.[65] As a general matter, Envirocare provides an apparent cost advantage for bulk materials that can be disposed of in the ten-inch lift[66] geometry used for bulk material disposal at that site. Substantially higher disposal prices are charged for materials that are too large to meet the 10-inch lift criterion. Envirocare has begun to accept wastes from commercial customers with substantially higher radioactive material concentrations than currently provided for in its contracts with DOE. Higher radioactive material concentrations are expected to carry higher price tags. In addition, such waste will need to be containerized, thereby bringing in some of the same types of waste preparation, packaging, and transportation costs associated with disposal at NTS and Hanford.

[63] At one extreme might be a truck carrying one shielded cask with one cubic meter of a high activity (e.g., equivalent to Nuclear Regulatory Commission Class C) waste that can only be disposed of at Hanford or NTS that could cost tens of thousands of dollars per cubic meter. At the other end of the spectrum are millions of cubic meters of low-level wastes disposed of in an on-site CERCLA cell at Hanford for a few tens of dollars per cubic meter.

[64] Pre-disposal costs are reported in Figure 4.1 as cost ranges with an indication of the midpoint cost in the range, rather than as weighted average costs. Given the significant ranges of costs and the fact that data for all wastes from all sites for the period evaluated were not available, cost ranges were considered to be more meaningful than the average cost.

[65] Current DOE estimates indicate that approximately 50% of the waste destined for off-site disposal is planned to be sent to commercial disposal facilities.

[66] The waste materials are placed in the disposal cells in nominal ten inch thick compacted layers, sandwiched between clean fill.

5. Only one meaningful commercial disposal alternative is currently available for DOE wastes: Envirocare. While other companies are attempting to obtain licenses for LLW (WCS and Envirosafe), there is no evidence that additional commercial disposal alternatives of relevance to DOE's LLW and MLLW disposal needs will be available in the near future.

6. Commercial disposal options do not exist for much of DOE's LLW and MLLW. Because of Envirocare's license limits, some of DOE's LLW and MLLW is not eligible for disposal at Envirocare. Until recently, Envirocare was limited in its WAC to low-activity radioactive waste. This situation is unlike that of the Hanford, NTS, Barnwell, and US Ecology LLW disposal facilities that can take higher-activity wastes. Envirocare has recently expanded its license to Class A limits (but not Class B or Class C), but has not yet entered into disposal contracts with DOE for the higher-activity containerized Class A wastes. Although commercial options beyond Envirocare exist, they have limited applicability to DOE because of state compact restrictions on the sites from which they can accept waste.

7. DOE's current commercial disposal contract prices are considerably more favorable than those generally available to commercial waste generators resulting at least in part from the availability of DOE's own disposal sites and volume discounts,[67] however, such pricing cannot be reasonably predicted beyond the current contract period. Historically, commercial radioactive waste disposal prices have fluctuated based on operating costs, projected waste volumes, host state tax levies, and competition for the available wastes. DOE's current contract with Envirocare expires on June 29, 2004, and contract prices will have to be renegotiated upon expiration of the contract. New Utah legislation imposes a state tax on waste disposal that will be charged to DOE at some time in the future. Whether the new taxes will be imposed when option years are exercised, when contract modifications are negotiated, or when new contracts are put into place is uncertain. Were it not for the availability of internal disposal options, prices to DOE for commercial disposal could conceivably be based on pricing schedules for commercial customers having similar waste types and waste volumes, resulting in substantially higher prices. With only one commercial disposal company offering a viable alternative to some DOE disposal needs and the pricing of that alternative being uncertain, DOE must use significant judgment when comparing life cycle costs for new long-term disposal capacity against the commercial option.

8. Disposal facility costs are extremely sensitive to disposal volumes: the larger the disposal volumes, the lower the per-unit-volume cost, and changes in quantity disposed of at any site can dramatically change the cost for that site. For example, the life cycle cost of the Hanford CERCLA facility, ERDF, is substantially lower than for other DOE or commercial facilities because of economies of scale from the enormous volumes of waste that facility handles. DOE projects that 7.5 million m^3 of waste will be disposed of in ERDF from FY 2002 through FY 2042. For comparison, DOE projects that 320,000 m^3 of waste will be disposed of in the DOE Idaho CERCLA cell and 1.3 million m^3 in the DOE Oak Ridge CERCLA cell.

9. Hanford's LLW disposal costs range from the lowest to the highest for DOE facilities. For non-CERCLA wastes, Hanford's costs are significantly higher than NTS, largely because Hanford maintains a full-service capability for all LLW waste types and activity levels and accepts very low waste volumes per shipment. In this regard, Hanford alone caters to small DOE waste generators who have unusual/difficult to handle wastes such as research wastes with unusual characteristics. Hanford maintains onsite ability to address difficult waste streams received from generators. Furthermore, the Hanford Low-Level Burial Grounds receive only 13% of the waste volume disposed of at NTS. In addition, Hanford handles some high-activity, remote-handled waste in high-integrity containers, adding to the cost. Because Hanford accepts small-volume

[67] DOE's high waste volumes lead to favorable commercial pricing.

waste shipments in small containers, Hanford handles large numbers of containers of unusual wastes. Although this approach raises the average cost, Hanford's costs nonetheless compare favorably with rates charged for LLW disposal by the comparable commercial facilities (i.e. the two full-service LLW disposal sites operating in the United States: Barnwell in South Carolina, and US Ecology in Washington).[68] Hanford's costs also compare favorably to rates that were proposed by other LLW compact facilities that have not yet materialized.

10. As recognized by the Committee, life cycle cost estimates represent an important economic metric because they represent the total cost to the government (i.e., they include "hidden" costs such as costs that are budgeted for separately). In particular, when evaluating the most cost-effective method for waste disposal, costs for waste preparation, packaging, and transportation must be considered in addition to the disposal facility cost in order to understand the option that truly represents the lowest cost to the taxpayer. Furthermore, the life cycle cost metric is of major relevance when deciding whether to build a new disposal facility or expand an existing facility.

11. DOE has experience in effectively using life cycle cost analysis to make waste disposal decisions. For example, as part of a decision on whether to build the CERCLA disposal facility at INEEL, DOE compared the life cycle cost of disposal on site with the cost of disposal at a commercial facility. That analysis provided useful input in determining whether on-site CERCLA disposal was more advantageous than using off-site disposal. In addition, at Oak Ridge, DOE used a cost analysis to decide to stop using the Interim Waste Management Facility because it determined that use of that facility is not cost-effective.

12. Ultimately, waste disposal decisions are made based on the specific characteristics of the waste and the actual cost of waste disposal. Envirocare has many different prices for different types of wastes, and, furthermore, Envirocare's prices beyond the period of its current contract with DOE are unknown. Because not all wastes can go to commercial facilities, continued operation of DOE facilities is necessary to meet DOE's waste disposal needs.

13. Hanford, NTS, and Envirocare all appear to fill necessary roles in DOE's cleanup of its sites, as do DOE's on-site disposal facilities. In the same manner that DOE's disposal capabilities result in competitive pricing from Envirocare, so also should the economies resulting from Envirocare's streamlined WAC and disposal approaches serve to remind DOE of the need to eliminate unnecessary red tape in its procedures and operations.

14. Cost estimates should be revisited at key decision points. Cost estimates for on-site and off-site disposal are extremely sensitive to assumptions regarding the volume of wastes needing disposal and the radioactivity level and hazardous chemical constituents in the waste, as well as duration of the cleanup, type (design) of disposal facility needed and special handling requirements, cost of off-site transportation, and price of commercial disposal. Changes in these factors could affect the balancing of costs and other factors considered while making cleanup decisions. Because of the sensitivity of decisions to these factors, and the fact that the critical parameter, waste volume projections, continues to change, cost estimates should be revisited periodically as cleanup plans unfold. The General Accounting Office[69] points out that revisiting cost comparisons is especially important in instances where DOE is aware that the scope or time frame of the cleanup effort has changed dramatically.

[68] These commercial sites do not meet DOE's disposal needs because of their high costs and restrictions on sites from which they can accept waste.

[69] GAO-01-441, "DOE Should Reevaluate Waste Disposal Options Before Building New Facilities," U.S. General Accounting Office, May 2001.

APPENDIX A. LIFE CYCLE COST ANALYSIS

Net Present Value and Cost-Effectiveness Analysis

This analysis follows the guidance presented in OMB Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, regarding performance of cost-effectiveness and net present value analysis. The circular defines cost-effectiveness analysis as "a systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective" and states that, "A program is cost-effective if, on the basis of *life cycle cost analysis* of competing alternatives, it is determined to have the lowest costs expressed in present value terms for a given amount of benefits." Note that, as stated by OMB Circular No. A-94,

> *The standard criterion for deciding whether a government program can be justified on economic principles is net present value – the discounted monetized value of expected net benefits (i.e., benefits minus costs). Net present value is computed by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement.*

Cost-effectiveness analysis differs from net present value analysis in that it does not consider the value of the benefits provided by the alternatives under consideration, because the benefits are considered the same for all alternatives. For the purposes of this analysis, the benefits of the alternatives – disposal of a unit of waste – were assumed equivalent for all alternatives, and only the difference in cost for disposal of a unit of waste was considered. Thus, for each DOE disposal facility the life cycle cost was estimated expressed in present value terms for disposal of a unit volume of waste.

Present Value Analysis

Present value analysis is a standard methodology that allows for cost comparisons of different alternatives on the basis of a single cost figure for each alternative. Present value analysis is a method used to evaluate alternative expenditures (including capital, operations and maintenance, closure, long-term stewardship, etc.) that occur at different times and put them on a common basis to make a fair cost comparison of alternatives.

Present value analysis requires a discounting of future dollars to reflect the time value of money. In other words, it is based on a dollar being worth more today than in the future because of potential returns that the dollar could earn if invested in alternate ways. In this manner, present value discounting reflects the potential productivity inherent in well-deployed capital.

The discount rate is the rate used in calculating the present value of future benefits and costs. The choice of a discount rate is important for comparing alternatives and making decisions, because the higher the discount rate, the lower the present value of future cash flows.

The discount rates for federal projects are specified annually by OMB in Circular No. A-94.[70] The choice of discount rate to use in the analysis depends on whether the benefits and costs are measured in real or nominal terms. Cost comparisons are often most readily accomplished using real or constant-dollar values (i.e., by measuring benefits and costs in units of stable purchasing power). A real value is not affected by

[70] Alternative discount rates, based on sound justification, may be used for sensitivity analyses.

general price inflation. This is the approach taken in this report, and all costs have been expressed in FY 2002 dollars. A real discount rate should be used to discount constant-dollar benefits and costs. Where future benefits and costs are given in nominal terms (i.e., in terms of future purchasing power of the date in question), a nominal discount rate that reflects expected inflation should be used.

A present value analysis of a waste disposal alternative involves four basic steps:

1. ***Define the period of analysis as equal to the project duration.*** For example, for a radioactive waste disposal facility, the period of analysis used in the cost estimate may be 150 years. Although some previous guides have suggested a period of analysis of 30 years, there are sound reasons why the period used for the present value analysis should not be shortened to less than the project duration. These reasons include cases in which the annual O&M costs are significant and cases in which major recurring costs, such as replacement or corrective maintenance, could reasonably be anticipated to occur periodically in the future.

2. ***Estimate the cash flows for each year of the project.*** The cash flows should be calculated using constant dollars throughout the duration of the project. For example, for the analyses presented in this report, all costs are estimated in FY 2002 dollars regardless of when activities occur. Estimating cash flows is not as simple as it may first appear; it requires analysts to reasonably forecast both long-range recurring and potential one-time costs.

3. ***Select a discount rate consistent with Appendix C to OMB Circular No. A-94.*** Real discount rates from Appendix C of Circular No. A-94 should be used to discount constant-dollar benefits and costs. The January 2001 update to Circular A-94 states that the real discount rate is 3.2%,[71] which is the value used in this report.

4. ***Calculate the present value.*** Because net present value (NPV) and present value (PV) formulas are built into Excel, the analyses can be readily performed using Excel spreadsheets.

Examples and Discussion of Present Value Analysis

Table A.1 shows a present value comparison of five disposition alternatives with different initial capital costs, annual O&M costs, and project duration. Alternative E has the highest total cost but the lowest present value, because much of its total cost occurs in the future and the present value of these future costs is small. The total cost of Alternative B is less than that of Alternative C, but its present value is higher because of its large upfront capital cost. In this analysis, Alternative E would be the preferred alternative.

Discounted values of even large costs incurred far in the future tend to be small. For example, for a 200-year project with a constant annual cost of $500,000/year at a 3.2% discount rate, 96% of the present value cost is incurred in the first 100 years, 80% in the first 50 years, and 62% in the first 30 years.

[71] Appendix C of OMB Circular No. A-94 is updated annually when the interest rate and inflation assumptions in the budget are changed.

Table A.1. Comparison of Present Value of Five Disposition Alternatives

Disposition Alternative	Initial Capital Cost ($000)	Annual O&M[a] Cost ($000)	Project Duration (Years)	Total Cost ($000)	Present Value at 3.2% ($000)
Alternative A	3,650	583	15	12,395	10,510[b]
Alternative B	10,800	548	30	27,240	21,269
Alternative C	2,850	696	50	37,650	20,097
Alternative D	5,500	230	80	23,900	12,109
Alternative E	2,000	200	220	46,000	8,244

[a]O&M = Operating and Maintenance.
[b]The Excel formula used to calculate present value for Alternative A =3650+PV(3.2%,15, -583)

Specific steps to follow in conducting an analysis include:

- ***Extract all hidden costs buried in overhead accounts***. Examples of "hidden costs" include surveillance and maintenance, safeguards and security, utilities, environmental monitoring, and recurring costs such as the need for continued permits, reporting, and other matters related to regulatory compliance, as well as replacement of caps and other infrastructure.

- ***Consider only incremental benefits and costs***. "Sunk" costs and realized benefits are ignored in calculation of net present value. Sunk costs are costs incurred in the past that will not be affected by any present or future decision.

- ***Discount all future benefits and costs***. Discounting reflects the time value of money; benefits and costs are worth more if they are experienced sooner. Thus, all future benefits and costs, including nonmonetized benefits and costs, should be discounted.

- ***Include the monetary value of future liabilities that may be associated with potential catastrophic events and hazardous substances***. For example, the analysis should consider potential future costs for repairs and remediation (if contaminants are released) in the event of catastrophic incidents such as building collapse or earthquakes.

- ***Fully include all project benefits.*** Such benefits could include the potential beneficial re-use of a building and/or land, and risk reductions resulting from action taken.

- ***Evaluate Uncertainty and Sensitivity***. The effects of uncertainty should be analyzed and reported, including the key sources of uncertainty; expected value estimates of outcomes; the sensitivity of results to important sources of uncertainty; and, where possible, the probability distributions of benefits, costs, and net benefits. Analyses should identify assumptions that may influence the selection of preferred alternative but which may reflect guesses with high degrees of uncertainty.

APPENDIX B. DISPOSAL SITE COST DATA

Disposal site cost data is provided for the following facilities:

1. Fernald OSDF (CERCLA)
2. Hanford LLBG
3. Hanford ERDF (CERCLA)
4. INEEL RWMC
5. INEEL ICDF (CERCLA)
6. Nevada Test Site
7. Oak Ridge EMWMF (CERCLA)
8. Savannah River Site Trenches
9. Savannah River Site Vaults

Figure B.1. Fernald On Site Disposal Facility (OSDF) Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11+	Total	Present Value
Projected LLW disposal volumes (m3)	221,725	279,068	374,639	389,930	122,331						1,387,693	1,306,526
Capital construction (x1000)	$10,600	$16,350	$15,100	$19,900	$26,900						$88,850	82,442
Disposal facility operation (x1000)	$11,400	$21,150	$19,900	$20,100	$25,100						$97,650	90,995
Closure (x1000)	$5,000	$2,500	$5,000	$10,000	$5,000						$27,500	25,624
Long-term stewardship (x1000)	$0	$0	$0	$0	$0	$5,049	$5,049	$5,049	$5,049	$1928/yr for 96 years	$205,284	61,020
Total annual cost (x1000)	$27,000	$40,000	$40,000	$50,000	$57,000	$5,049	$5,049	$5,049	$5,049	$185,088	$419,284	$260,081

Results Summary:
Total Life Cycle Cost - Present Value $260 million
Unit Cost $187/m^3

Notes:
Fernald provided a long-term stewardship cost estimate for the entire site, which includes activities other than LTS for the OSDF. Therefore, this probably over-estimates the LTS cost associated with the OSDF.

Figure B.2. Hanford Low-Level Burial Grounds (LLBG) Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29+	Total	Present Value
Projected LLW disposal volumes (m3)	4131	3898	4277	4121	3526	3526	3526	3526	3526	3191	3191	3191	3191	3191	2780	2780	2780	2780	2780	2038	2038	2038	2038	2038	1463				75,565	55,933
Capital construction (x1000)	$0	$507	$506																										$1,013	$966
Disposal facility operation (x1000)	$6,858	$7,267	$7,137	$4,851	$4,751	$7,013	$6,217	$6,237	$6,489	$5,883	$5,782	$6,615	$6,081	$5,776	$6,578	$6,385	$5,886	$6,524	$5,684	$5,758	$6,286	$5,516	$5,718	$6,129	$5,348				$152,769	$108,230
Closure (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$79,000			$79,000	$35,945
Long-term stewardship (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$500/year for 100 years			$50,000	$7,022
Total annual cost (x1000)	$6,858	$7,774	$7,643	$4,851	$4,751	$7,013	$6,217	$6,237	$6,489	$5,883	$5,782	$6,615	$6,081	$5,776	$6,578	$6,385	$5,886	$6,524	$5,684	$5,758	$6,286	$5,516	$5,718	$6,129	$5,348	$79,500	$500	$49,000	$282,782	$152,164

Results Summary:
Total Life Cycle Cost - Present Value $152 million
Unit Cost $2,014/$m^3$

Notes:
1. FY02 costs of $7.3M consist of operations costs ($3.1M) and direct-funded activities ($4.2M) such as safety, regulatory compliance, inspection, and permitting. The direct funding provides for a pro-rated share of the program management activities for the Waste Management Project at Hanford and for a ready-to-serve status of the disposal facility, as well as monitoring and surveillance of legacy wastes. Legacy wastes include retrievably-stored TRU, TRU caissons, special wastes in storage, and disposed mixed waste. The $4.2 million funding for direct activities has been reduced to account for monitoring of non-LLW legacy wastes. This results in total (operations and direct funding) FY02 costs of $6.9 million.
2. Hanford does not have specific plans to close in FY26. However beyond that date plans and projected waste quantities are speculative.
3. Hanford's estimate of closure costs is based on closing 213 acres at $370,000 per acre. Closure costs are based on closing the entire acreage of the burial grounds, i.e., the $79M closure cost estimate includes the cost of closure for past waste emplacements, not simply the 2.7 million cubic feet of waste projected to be emplaced between FY2002 and FY2026.
4. Hanford does not have cost estimates for long-term stewardship. We have assumed $500K/year for 100 years.

Figure B.3. Hanford ERDF Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Projected LLW disposal volumes (m3)	249,767	220,560	190,628	241,820	215,591	198,288	244,611	262,930	318,138	415,215	252,230	327,310	335,105	334,692	334,920	335,037	290,244	292,179	230,750	255,267	268,095	284,899
Capital construction (x1000)	$0	$0	$0	$6,925	$3,463	$0	$0	$0	$6,925	$3,463	$0	$0	$5,194	$5,194	$0	$0	$2,030	$8,118	$2,030			
Disposal facility operation (x1000)	$8,764	$7,039	$6,278	$7,579	$6,911	$6,470	$7,648	$8,113	$9,640	$12,558	$7,780	$9,752	$9,950	$9,939	$9,945	$9,948	$8,810	$8,859	$7,298	$7,921	$8,247	$8,686
Closure (x1000)	$0	$254	$0	$254	$0	$254	$0	$254	$0	$4,835	$9,416	$4,581	$254	$0	$254	$254	$0	$254	$5,174	$8,877	$3,449	$254
Long-term stewardship (x1000)																						
Total annual cost (x1000)	$8,764	$7,293	$6,278	$14,758	$10,374	$6,724	$7,648	$8,367	$16,565	$20,856	$17,196	$14,333	$15,398	$15,133	$10,199	$10,202	$10,840	$17,231	$14,502	$16,798	$11,696	$8,940

	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37	FY38	FY39	FY40	FY41	FY42	FY43	FY44	FY45	FY46	FY47+	Total	Present Value
Projected LLW disposal volumes (m3)	293,149	292,197	175,093	6,931	7,526	4,436	3,511	5,046	5,046	5,046	100,000	100,000	100,000	100,000	100,000	100,000	1,104	1,104	1,104						7,499,569	4,984,288
Capital construction (x1000)																									$43,342	$31,482
Disposal facility operation (x1000)	$8,883	$8,859	$5,883	$486	$496	$422	$253	$322	$322	$322	$3,340	$3,340	$3,340	$3,340	$3,340	$3,340	$253	$253	$253						$235,182	$155,844
Closure (x1000)	$0	$254	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$254	$0	$0	$9,162	$9,162		$57,450	$29,929
Long-term stewardship (x1000)																								$500/yr for 100 yrs	$50,000	$3,740
Total annual cost (x1000)	$8,883	$9,113	$5,883	$486	$496	$422	$253	$322	$322	$322	$3,340	$3,340	$3,340	$3,340	$3,340	$3,340	$253	$253	$507	$0	$0	$9,162	$9,162	$50,000	$385,974	$220,995

Results Summary:

Total Life Cycle Cost - Present Value $221 million

Unit Cost $29/m^3

Notes:
1. The FY 43-44 period for which no costs are shown is for ground settling prior to installation of the final cell covers.
2. ERDF does not have cost estimates for long-term stewardship. We have assumed $500K/year for 100 years.

Figure B.4. INEEL RWMC Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23+	Total	Present Value
Projected LLW disposal volumes (m3)	1659	2326	4797	3763	3718	3718	3718	3718	3718	2175	2175	2175	2175	2175	1431	1431	1431	1431	1431				49,165	39,270
Capital construction (x1000)	$0	$1,940	$0	$0	$0	$0	$1,940	$0	$0	$0	$0	$1,940											$5,820	$4,858
Disposal facility operation (x1000)	$1,681	$2,123	$2,000	$1,446	$1,291	$1,291	$1,291	$1,291	$1,291	$1,075	$1,075	$1,075	$1,075	$1,075	$993	$993	$993	$993	$993				$24,045	$19,088
Closure (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$4,000			$4,000	$2,199
Long-term stewardship (x1000)																				$500/year for 100 years			$50,000	$8,483
Total annual cost (x1000)	$1,681	$4,063	$2,000	$1,446	$1,291	$1,291	$3,231	$1,291	$1,291	$1,075	$1,075	$3,015	$1,075	$1,075	$993	$993	$993	$993	$993	$4,500	$500	$49,000	$83,865	$34,627

Results Summary:
Total Life Cycle Cost - Present Value $35 million
Unit Cost $704/m^3

Notes:
Closure and long-term stewardship cost estimates were not available from INEEL because the facility will be closed as part of a much larger closure of the entire RWMC. This closure will be done as a CERCLA closure, and the CERCLA closure process is currently in the RI/FS stage, with a final ROD planned to be issued in FY03. Until the ROD is issued, the closure method and long-term stewardship programs are unknown. For the purposes of this analysis, costs were estimated based on benchmarks from other sites: closure costs were assumed to be $4 million ($400,000 per acre for 10 acres), and long-term stewardship was assumed to cost $500k/year for 100 years. The $4 million closure cost is based on closing the entire LLW disposal facility, which is projected to contain 2.8 million cubic feet of waste; that is, the cost is not limited to capping the 1.7 million cubic feet that are projected to be emplaced from 2002 through 2020.

Figure B.5. INEEL ICDF Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16 - FY20	FY21 - FY25	FY26 - FY30	FY31 - FY35	FY36 - FY40	FY41 - FY45	FY46 - FY50	FY51+	Total	Present Value
Projected LLW disposal volumes (m3)	0	32,403	102,497	112,435	46,731	7,144	15,023	55	55	55	55												316,453	289,841
Capital construction (x1000)	$14,529	$5,924																					$20,453	$20,269
Disposal facility operation (x1000)	$0	$4,208	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684												$19,364	$16,665
Closure (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$9,105											$9,105	$6,439
Long-term stewardship (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,454	$1,454	$702/yr for 5 years	$290/yr for 5 yrs	$211/yr for 5 yrs	$112/yr for 5 yrs	$93/yr for 5 yrs	$60/yr for 5 yrs	$39/yr for 5 yrs	$30/yr for 63 yrs	$12,333	$5,967
Total annual cost (x1000)	$14,529	$10,132	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$1,684	$9,105	$1,454	$1,454	$3,510	$1,450	$1,055	$560	$465	$300	$195	$1,890	$61,255	$49,340

Results Summary:
Total Life Cycle Cost - Present Value $49 million
Unit Cost $156/m^3

Figure B.6. Nevada Test Site LLW Disposal Facility Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Projected LLW disposal volumes (m^3)	46,690	74,949	74,007	80,520	87,118	37,992	25,134	8,342	20,402	16,490
Capital construction (x1000)	$519	$593	$593	$593	$593	$0	$0	$0	$0	$575
Disposal facility operation (x1000)	$12,862	$12,753	$12,456	$12,182	$11,767	$11,215	$11,140	$9,479	$9,399	$10,401
Closure (x1000)	$253	$0	$122	$0	$0	$122	$260	$279	$1,525	$8
Long-term stewardship (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$78
Total annual cost (x1000)	$13,634	$13,346	$13,171	$12,775	$12,360	$11,337	$11,400	$9,758	$10,924	$11,062

	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY 2022 – FY 121	Total	Present Value
Projected LLW disposal volumes (m^3)	20,742	2,549	18,240	9,376	1,516	4,590	22,827	10,020	9,376	2,206		573,086	492,786
Capital construction (x1000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0		$3,466	$3,146
Disposal facility operation (x1000)	$10,853	$9,771	$10,535	$9,759	$9,512	$9,698	$10,675	$10,018	$9,267	$7,741		$211,483	$162,438
Closure (x1000)	$0	$120	$0	$0	$111	$0	$0	$426	$355	$2,273		$5,854	$3,959
Long-term stewardship (x1000)	$78	$78	$78	$78	$78	$78	$78	$78	$78	$78	see separate data	$65,886	$11,206
Total annual cost (x1000)	$10,931	$9,969	$10,613	$9,837	$9,701	$9,776	$10,753	$10,522	$9,700	$10,092	$65,028	$286,689	$180,748

Results Summary:
Total Life Cycle Cost - Present Value $181 million
Unit Cost $315/m^3

Notes:
1. Disposal at NTS is not projected to end in FY21, however waste volumes after that time are unknown.
2. Detailed breakdown on annual long-term stewardship costs from FY 2022 through FY 2121 provided separately by NTS.

Figure B.7. Oak Ridge EMWMF Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	Total	Present Value
Projected LLW disposal volumes (m3)	54,896	76,458	188,519	230,198	204,702	159,835	225,016	114,595	56,149			1,310,368	1,154,275
Capital construction (x1000)	$18,810	$0	$6,190	$13,154	$6,440	$20,319	$21,318					$86,231	$77,273
Disposal facility operation (x1000)	$7,528	$5,788	$7,190	$7,750	$7,512	$7,043	$7,890	$6,641	$6,012			$63,354	$56,109
Closure (x1000)	$0	$0	$0	$6,165	$0	$8,537	$13,278	$1,797	$0	$18,697		$48,474	$39,417
Long-term stewardship (x1000)	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000		$10,000	$8,714
Total annual cost (x1000)	$27,338	$6,788	$14,380	$28,069	$14,952	$36,899	$43,486	$9,438	$7,012	$19,697	$0	$208,059	$181,513

Results Summary:
Total Life Cycle Cost - Present Value $182 million
Unit Cost $139/m^3

Notes:
Long-term stewardship costs reflect funding of a Perpetual Care Fund managed by the State of Tennessee.

Figure B.8. Savannah River Site Trenches Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29+	Total	Present Value
Projected LLW disposal volumes (m3)	4974	5524	4826	3508	3753	65429	2036	2086	1836	5639	5639	5639	5639	5639	1625	1625	1625	1625	1625	1603	1603	1603	1603	1603	1461				139,768	111,737
Capital construction (x1000)																													$0	$0
Disposal facility operation (x1000)	$646	$823	$789	$615	$617	$3,991	$426	$426	$426	$915	$915	$915	$915	$915	$337	$297	$297	$297	$297	$337	$297	$297	$297	$297	$269				$16,653	$12,800
Closure (x1000)																										$3,800			$3,800	$1,729
Long-term stewardship (x1000)																										$250/year for 100 years			$25,000	$3,511
Total annual cost (x1000)	$646	$823	$789	$615	$617	$3,991	$426	$426	$426	$915	$915	$915	$915	$915	$337	$297	$297	$297	$297	$337	$297	$297	$297	$297	$269	$4,050	$250	$24,500	$45,453	$18,041

Results Summary:

Total Life Cycle Cost - Present Value $18 million

Unit Cost $129/m^3

Notes:

1. Beyond FY2026 plans and projected waste quantities are highly speculative. Therefore, for the purposes of this analysis, disposal operations are assumed to stop in FY2026, followed by closure and long-term stewardship.
2. For closure costs, SRS estimated $430,000 per acre for a closure cap. Closure costs are based on closing all of the trenches, i.e., the cost estimate includes the cost of closing the one currently existing trench as well as future trench capacity that will be needed between 2002 and 2026.
3. Because the SRS vaults and trenches are in the same physical area, we assumed one LTS program for both, at a cost of $500,000 per year for 100 years, for the vaults and trenches combined (i.e., $250,000 per year each).

Figure B.9. Savannah River Site Vaults Life Cycle Cost Analysis

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29+	Total	Present Value
Projected LLW disposal volumes (m3)	1861	1749	1551	1284	1293	1116	1116	946	938	1483	1483	1483	1483	1483	830	830	830	830	830	661	661	661	661	661	641				27,365	20,452
Capital construction (x1000)	$15	$576	$1,108	$2,515	$2,516	$5,582	$6,251	$5,757	$0	$0	$392	$1,730	$1,462	$3,971	$3,971	$124	$9,085	$10,423	$8,726										$64,204	$45,001
Disposal facility operation (x1000)	$846	$587	$651	$448	$449	$378	$378	$340	$340	$529	$529	$529	$529	$529	$302	$302	$302	$302	$302	$227	$227	$227	$227	$227	$227				$9,934	$7,481
Closure (x1000)																										$1,300			$1,300	$591
Long-term stewardship (x1000)																										$250/year for 100 years			$25,000	$3,511
Total annual cost (x1000)	$861	$1,163	$1,759	$2,963	$2,965	$5,960	$6,629	$6,097	$340	$529	$921	$2,259	$1,991	$4,500	$4,273	$426	$9,387	$10,725	$9,028	$227	$227	$227	$227	$227	$227	$1,550	$250	$24,500	$100,438	$56,584

Results Summary:

Total Life Cycle Cost - Present Value $57 million

Unit Cost $2,068/m^3

Notes:

1. Beyond FY2026 plans and projected waste quantities are highly speculative. Therefore, for the purposes of this analysis, disposal operations were assumed to cease in FY2026, followed by closure and long-term stewardship.
2. For closure costs, SRS estimated $430,000 per acre for a closure cap. Closure costs are based on closing all of the vaults, i.e., the cost estimate includes the cost of closing the one currently existing vault as well as future vault capacity that will be needed between 2002 and 2026.
3. Because the SRS vaults and trenches are in the same physical area, we assumed one LTS program for both, at a cost of $500,000 per year for 100 years, for the vaults and trenches combined (i.e., $250,000 per year each).

APPENDIX C. RELATED STUDIES

U.S. Department of Energy, *On-Site Versus Off-Site Soil and Debris Disposal Comparison for the ICDF Complex*, October 2001

U.S. Department of Energy, *LLW/MLLW Generator Conference*. copies of slides. June 26, 2001.

U.S. General Accounting Office, *DOE Should Reevaluate Waste Disposal Options Before Building New Facilities*, GAO-01-441, May 2001.

U.S. Department of Energy, Office of Inspector General, *Utilization of the Department's Low-Level Waste Disposal Facilities*, DOE/IG-0505, May 2001.

U.S. General Accounting Office, *Low-Level Radioactive Wastes: Department of Energy Has Opportunities to Reduce Disposal Costs*, GAO/RCED-00-64, April 2000.

U.S. Department of Energy, *Life-Cycle Cost Comparisons of Onsite versus Offsite Disposal of Department of Energy Low-Level and Mixed Low-Level Radioactive Waste*, March 2000.

Cost Engineering Report on Environmental Restoration Waste Disposal Facilities. February 2000.

U.S. Department of Energy, *Profiles of Environmental Restoration CERCLA Disposal Facilities*, DOE/EM-0387, July 1999.

U.S. Department of Energy, *Commercial Disposal Policy Analysis for Low-Level and Mixed Low-Level Wastes*, March 9, 1999.

U.S. Department of Energy, *Information Package on Pending Low-Level Waste and Mixed Low-Level Waste Disposal Decisions to Be Made Under the Final Waste Management Programmatic Environmental Impact Statement*, September 1998

U.S. Department of Energy, Office of Inspector General, *Audit Report: Disposal of Low-Level and Low-Level Mixed Waste*, DOE/IG-0426, September 1998.

U.S. Department of Energy, *Low-Level Waste Disposal Cost Comparison Report*, July 15, 1997.

U.S. Department of Energy, Office of Inspector General, *Idaho Operations Office Mixed Low-Level Waste Disposal Plans*, DOE/IG-0527, September 2001.

APPENDIX D. SITE SPECIFIC GENERATOR COST INSIGHTS ON PRE-DISPOSAL COSTS

In general, DOE generators have observed higher pre-disposal costs for wastes sent to NTS and Hanford than for waste sent to Envirocare. Although the cost differences noted appear to exist, they largely result from the substantial differences in the types of wastes accepted at those sites as compared to those accepted at Envirocare. These insights are summarized below.

Rocky Flats Environmental Technology Site (RFETS)—RFETS indicated that there are no identifiable cost differences between using NTS or Envirocare disposal because they have one waste characterization program they use regardless of where the waste goes. Furthermore, all waste disposal programs at RFETS are, and would continue to be, established to comply with federal, state, and local requirements and DOE Orders relative to packaging, transportation, disposal, QA/QC, and safety, regardless of individual disposal facility requirements. RFETS has not recently shipped waste to Hanford. Differences in transportation costs can occur depending upon the waste type and waste packaging approach used.

Chicago Operations Office—The sites associated with the DOE Chicago Operations Office are primarily research and development institutions (i.e., Argonne National Laboratory-East, Argonne National Laboratory-West, Brookhaven National Laboratory, Ames, and Princeton) that have both remediation wastes and ongoing operational wastes. In general, the waste quantities are smaller than for DOE weapons sites and may have unique properties consistent with the laboratory research that resulted in their generation. DOE-Chicago indicated that meeting the waste acceptance criteria for NTS and Hanford is more time- and resource-intensive than those for Envirocare. The authors believe this to be at least partially a result of the waste being sent to Hanford and/or NTS not being within the Envirocare contract waste acceptance criteria.

Oak Ridge Operations Office—The Oak Ridge Operations Office includes several hundred CERCLA and legacy waste streams that are addressed by multiple subcontractors at multiple facilities. Oak Ridge has on-site LLW operational waste disposal capabilities, will have on-site CERCLA disposal, and also uses NTS and Envirocare. Waste generation and disposal data were gathered for Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex, East Tennessee Technology Park (ETTP), and Paducah in Kentucky. Pre-disposal costs for legacy LLW from ETTP and Paducah over the past two years to all sites ranged from \$500/m^3 to \$7,200/m^3 with an average of \$1,400/ m^3. Oak Ridge indicated that treatment before disposal was minimal (i.e., the wastes were conventional waste forms typical of early remediation and D&D tasks). In FY 2000/2001 Oak Ridge spent \$4.7 million to prepare and ship 703 m^3 of LLW to NTS at an average unit cost of \$6,600/m^3. Also in FY 2000/2001, Oak Ridge spent \$5.4 million to prepare and ship 6,241 m^3 of LLW to Envirocare at an average unit cost of \$870/m^3. The cost difference between NTS and Envirocare is largely attributable to the large waste volume over which costs were amortized; bulk transportation for the Envirocare shipments; and low characterization costs resulting from the waste being bulk, low-level. Oak Ridge CERCLA wastes are primarily characterized through the RI/FS process. CERCLA wastes are typically excavated, loaded directly into trucks or containers, and transferred to the on-site cell or off-site facility, as required.

Ohio Field Office—The DOE Ohio Field Office includes five sites that generate LLW and MLLW: Fernald Environmental Management Project (Fernald), Miamisburg Environmental Management Project, Columbus Environmental Management Project, West Valley Demonstration Project, and RMI Extrusion Plant Decommissioning Project (Ashtabula). The DOE Ohio sites ship waste to both commercial and DOE disposal sites. Pre-disposal cost information for this study was developed using data from one of those sites, Fernald, which parallels approaches used at the other four sites.

The Fluor-Fernald Waste Generator Services group manages all wastes being placed into the on-site disposal facility and those wastes exiting the Fernald site to other disposal sites. Fernald has a Waste Certification Official program to interface and oversee wastes going to NTS. Fernald does not presently use Hanford. Fernald also has a Waste Acceptance Organization to oversee and interface with Envirocare. Both programs perform 100% visual inspection of wastes during packaging. Fernald indicates that an additional 4 to 8 full-time staff are necessary to support NTS characterization requirements. NTS waste characterization requires approximately three months per shipment as compared to one month for Envirocare shipments. This results in additional predisposal NTS costs of approximately $\$400/m^3$. Fernald has approximately 27 waste streams that go to NTS and shipped nearly 6000 m^3 to NTS from FY 1998 through FY 2000.

APPENDIX E. SCOPE AND METHODOLOGY

In its evaluation of DOE's waste disposal costs, YAHSGS interviewed DOE, DOE contractor, and commercial disposal site personnel at DOE waste generator and disposal sites and at Envirocare of Utah. YAHSGS also interacted with DOE and DOE contractor personnel, including DOE Headquarters personnel, by telephone and e-mail. YAHSGS' review included information obtained through those interactions, as well as information via a formal DOE data call to waste disposal and generator sites. Also included was the review of data in DOE's IPABS database. Interviews with DOE and contractor officials were conducted at DOE Headquarters, DOE-Richland, the Idaho National Engineering and Environmental Laboratory, the Nevada Test Site, the Oak Ridge Reservation, and the Rocky Flats Environmental Technology Site. In addition, YAHSGS visited a commercial disposal site, Envirocare of Utah, and met with representatives of the state of Utah. YAHSGS further contacted DOE officials at Chicago Operations Office, the Fernald Environmental Management Project, the Savannah River Site, and the Weldon Spring Site. Collectively, these sites account for generation and disposal of the majority of DOE's projected LLW and MLLW. YAHSGS would like to acknowledge the excellent information and cooperation it received from all of the individuals and companies contacted during the performance of this study, in particular, those listed below who provided information that was essential to the analyses.

DOE Headquarters	Karen Guevara, DOE; Helen Belencan, DOE; Tina Witmer, DOE; Steve Loftus, MACTEC
Chicago Operations	Tony Bindokas, DOE
Envirocare of Utah	Al Rafati; Dan Burns; Ken Alkema; Kaylin Loveland; Johnny Bowne
Fernald Environmental Management Project	John Sattler, DOE; Jerry Erfman, Fluor-Fernald
Hanford Site	Rudy Guercia, DOE; John Lang, Fluor Hanford; Gregg Frank, Bechtel Hanford
INEEL	Talley Jenkins, DOE; Jeff Shadley, DOE; Bob Stump, DOE; Bob Piper, BBWI; Roger Seitz, BBWI; Sonya Pelot, BBWI; Marty Doornbos, BBWI
Nevada Test Site	Frank DiSanza, DOE; Max Dolenc, Bechtel Nevada; Michael Noland, Bechtel Nevada; Thomas Mulkey, Bechtel Nevada; Bruce Becker, Bechtel Nevada
Oak Ridge Reservation	Bill McMillan, DOE; John Patterson, Bechtel-Jacobs Corporation (BJC); John Clayton, BJC; Bob Orewiler, BJC; Ray Riner, BJC; Angel Rivera, BJC; Dayne Thomas, BJC; Lance Mezga, UT-Battelle; Danny Nichols, BNFL
Rocky Flats Environmental Technology Site	Fran Geurink, DOE; Scott Anderson, Kaiser-Hill (K-H); Ray Geimer, K H, Dean Lobdell, K-H; Dan Salyers, K-H; Beth Telesmanich, K-H; Allen Schubert, K-H, Mike Glaser, CTS
Savannah River Site	Howard Pope, DOE; Sonny Goldston, Westinghouse Savannah River Company (WSRC); Ferris Gunnels, WSRC; Gary Bunker, WSRC
State of Utah	Bill Sinclair; Dane Finerfrock

On-Site Versus Off-Site Cost Comparison

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ABSTRACT

This report presents the current estimated costs for (1) on-site disposal of Idaho National Engineering and Environmental Laboratory (INEEL) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) soils and debris at the INEEL CERCLA Disposal Facility (ICDF) and (2) off-site disposal at a commercial disposal facility. The ICDF is the facility that is currently being constructed at the Idaho Nuclear Technology and Engineering Center (INTEC), which include the landfill and evaporation pond along with facilities to decontaminate, treat, and operate the ICDF Complex. Under the offsite cost estimates, there are two alternatives considered. The first of these offsite alternatives is to send all of the waste offsite for treatment as necessary and disposal. The second offsite alternative is to treat the waste onsite and then send the waste offsite for disposal.

In comparing the cost of on-site versus off-site disposal of INEEL CERCLA waste, the new cost for onsite disposal is estimated to be $96 million with offsite treatment and disposal at $537 million. The cost estimate in the Operable Unit 3-13 Feasibility Study Supplement (DOE-ID 1998a) for onsite disposal was $234 million and for offsite treatment and disposal the cost was estimated at $$713 million. Both the cost of onsite and offsite disposal have been reduced. The reduction for onsite disposal is 59% and for offsite the reduction is 25%. The GAO had previously stated that the cost of offsite disposal could be reduced by 22%, which is comparable to the reduction calculated in this report.

When considering comparable waste disposal approaches (disposal of waste as mixed low-level waste), the cost of onsite disposal is less one-fifth the cost of off-site treatment and disposal. However, changing the evaluating and disposal criteria to allow for onsite disposal of treated mixed low-level waste as low-level waste the cost of offsite disposal can be reduced to $190 million. This results in the cost of offsite disposal to be twice the cost of onsite disposal. However, this alternative would require delisting the waste streams prior to disposal.

However, even based on changing the requirements for disposal of the waste streams, it is not conceivable that the cost of off-site disposal could be reduced to the current cost of on-site disposal at the ICDF Complex.

On-site Versus Off-Site Cost Comparison

1. INTRODUCTION

This report presents the current estimated costs for (1) on-site disposal of Idaho National Engineering and Environmental Laboratory (INEEL) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) soils and debris at the INEEL CERCLA Disposal Facility (ICDF) and (2) off-site disposal at a commercial disposal facility. The ICDF is the facility that is currently being constructed at the Idaho Nuclear Technology and Engineering Center (INTEC), which include the landfill and evaporation pond along with facilities to decontaminate, treat, and operate the ICDF Complex. Under the offsite cost estimates, there are two alternatives considered. The first of these offsite alternatives is to send all of the waste offsite for treatment as necessary and disposal. The second offsite alternative is to treat the waste onsite and then send the waste offsite for disposal.

In evaluating the remedial action alternatives in the Operable Unit (OU) 3-13 Feasibility Study (FS) Supplement Report (DOE-ID 1998a), cost estimates were developed for both on-site and off-site disposal alternatives. This cost information, along with the other evaluation criteria, was presented in the OU 3-13 Proposed Plan (DOE-ID 1998b). During the public comment period on the OU 3-13 Proposed Plan, comments dealing with the cost of on-site versus off-disposal were submitted for consideration in development of the OU 3-13 Record of Decision (ROD) (DOE-ID 1999).

In the OU 3-13 ROD, on-site disposal at the ICDF was selected as a component of the remedial action for dealing with some of the contaminated surface soils that exceed risk-based contaminant concentrations. These surface soils are referred to in the OU 3-13 ROD as Other Surface Soils (Group 3). In addition, as discussed in Section 11.1.3 of the OU 3-13 ROD, the ICDF is intended to "...function as an INEEL-wide disposal facility to accommodate disposal of CERCLA soils and debris...."

The OU 3-13 ROD also contained a requirement to evaluate the "...life cycle cost effectiveness of on- or off-site disposal and compliance with DOE policy...." This requirement was included in the OU 3-13 ROD to make sure that on-site disposal at the ICDF is the cost-effective option in comparison to off-site disposal. In addition, the Department of Energy's (DOE's) current policy (DOE 1999) is to utilize on-site disposal capacity preferably to off-site disposal capacity at commercial disposal facilities.

Two recent General Accounting Office (GAO) reports (GAO 2000 and GAO 2001) consider the cost-effectiveness of on-site versus off-site disposal. In the GAO report titled *Nuclear Cleanup, DOE Should Reevaluate Waste Disposal Options Before Building New Facilities* (GAO 2001), the GAO stated that the cost of off-site disposal could be reduced. From this report, GAO estimated that the cost of off-site disposal could be reduced by 22% provided that the waste being considered for off-site disposal was only low-level waste and was able to meet the off-site disposal facilities' waste acceptance criteria.

This report discusses several issues that contribute to on-site and off-site disposal costs. The volume and characteristics of the various waste streams destined for the ICDF landfill have changed since the analysis that was conducted for the OU 3-13 FS Supplement Report, on which the OU 3-13 ROD was based. The cost estimate for the onsite disposal at the ICDF is based on the final designs and construction specifications for the ICDF landfill and evaporation pond (DOE-ID 2002a) and the Staging, Storage, Sizing, and Treatment Facility (DOE-ID 2002b). These issues, in addition to the requirements in the OU 3-13 ROD and GAO reports, are the basis for conducting this updated evaluation of the cost of on-site disposal versus off-site disposal.

This report is organized as follows:

Section 2 discusses the classification of waste streams from the release sites and deactivation, decommissioning, and dismantlement (D&D&D) projects being considered for disposal in the ICDF landfill. There have been changes in our knowledge of the contaminants and media types from the release sites between the publication of the OU 3-13 FS Supplement Report (Appendix A) (October 1998), on which the OU 3-13 ROD was based, and the current waste streams being considered for the ICDF Complex in the ICDF Complex Approved Waste Streams (DOE-ID 2002c).

Section 3 presents the volumes of each waste type for the release sites and D&D&D projects being considered for disposal in the ICDF landfill. There have been changes in the release sites waste classifications and expected volumes between the publication of the OU 3-13 FS Supplement Report (Appendix B), on which the OU 3-13 ROD was based, and the current waste streams being considered for the ICDF Complex in the ICDF Complex Approved Waste Streams (DOE-ID 2002c).

Section 4 presents a summary of the cost estimate for on-site disposal using the ICDF Complex. There have been significant changes in the cost estimates for on-site disposal between the publication of the OU 3-13 FS Supplement Report (Appendix D), on which the OU 3-13 ROD was based, and the current cost estimate presented in Section 4 and Appendix C.

Section 5 presents a summary of the cost estimate for off-site disposal at a commercial disposal facility. There have been significant changes in the cost estimates for off-site disposal between the publication of the OU 3-13 FS Supplement Report (Appendix F), on which the OU 3-13 ROD was based, and the current cost estimate presented in Section 5 and Appendix E. Section 5 and Appendix E also presents a summary of the cost estimate for onsite treatment with offsite disposal.

Section 6 presents conclusions and comparisons between the estimated cost of disposal at the ICDF Complex and off-site based on the cost estimates presented in Sections 4 and 5. In addition, Section 6 also provides a comparison of the cost of on-site and off-site disposal based on the OU 3-13 FS Supplement Report cost estimates.

2. RELEASE SITE WASTE CLASSIFICATIONS

For the analysis of the waste classifications, some additional analysis beyond the information and analysis in the OU 3-13 FS Supplement Report was conducted. In the OU 3-13 FS Supplement Report, the classification of waste was based on several criteria. Waste streams from INEEL CERCLA release sites waste streams were classified using a combination of process knowledge and analytical data. Release sites were classified as low-level waste (LLW), based on analytical data showing radionuclides to be present in the release site exceeding INEEL background concentrations. In the case of hazardous waste classifications, release sites were classified as being hazardous waste (haz waste) if the analytical data showed that the waste was characteristic for Resource Conservation and Recovery Act (RCRA) metals as demonstrated by Toxic Characteristic Leaching Procedure (TCLP) results with background concentrations subtracted. If no TCLP results were available, the 20X rule was applied to the maximum concentrations for the RCRA metals in the waste stream, and waste streams exceeding the 20X concentrations were classified as potentially hazardous waste. Also, if the release site was associated with a process having listed waste, the listed hazardous waste codes were applied to the release site, making the waste a hazardous waste. For waste streams that contained both radionuclides and hazardous waste components, the waste stream was classified as a mixed low-level waste (MLLW). For the waste expected to be generated by the D&D&D projects, the D&D&D Parametric Model was used (DOE-ID 2000).

In the ICDF Complex Approved Waste Streams (DOE-ID 2002c [this information will need to be updated based on the completed waste approval forms (WAFs) as the evaluation was conducted using the WAFs from the SSSTF Draft Final RD/RAWP]), 44 sites are identified for disposal in the ICDF landfill. These release sites are from Waste Area Group (WAG) 1 (Test Area North [TAN], which includes the Technical Support Facility [TSF]); WAG 3 (Idaho Nuclear Technology and Engineering Center [INTEC], formerly known as the Chemical Processing Plant [CPP]); WAG 4 (Central Facilities Area [CFA]); and WAG 5 (Auxiliary Reactor Area [ARA. In addition, the OU 3-14 remedial investigation (RI) is expected to generate investigation-derived waste (IDW) soils which are being considered for disposal at the ICDF landfill. This soil volume is expected to be generated primarily from the investigation of release sites CPP-28 and CPP-31. These revised characteristics and estimates of waste volumes for disposal are being used to update the cost estimates for on-site and off-site disposal.

The new analysis essentially used the same criteria as the OU 3-13 FS Supplement Report, discussed above. However, for the evaluation of potential hazardous characteristics for sites lacking TCLP results, the concentrations presented on the WAFs, which are either the maximum or 95% upper confidence level depending on the number of samples, were used in the assessment of the RCRA 20X rule. Also, for the D&D&D projects, the D&D&D Parametric Model continued to be used. However, the information provided in the CWID Report (DOE-ID 2000) for D&D&D did not distinguish between the various WAGs and was updated for this analysis of the waste characterization. The current information regarding contaminants and types for the release sites and D&D&D projects is presented in Table 1. Appendix A contains the information on contaminants and types used for the OU 3-13 FS Supplement Report.

3. RELEASE SITE WASTE VOLUMES

In developing the OU 3-13 FS Supplement Report, an expected volume of contaminated soils and debris of 465,312 yd^3 was identified as requiring disposal. This volume did not account for any swell due to excavation and recompaction. For sizing purposes and to account for some swell, a disposal volume of 510,000 yd^3 was authorized in the OU 3-13 ROD. For the volumes used in the WAFs, the size of the WAG 3 release sites contained in the OU 3-13 ROD was used. In the case of the other WAGs release sites, the volumes were obtained from personnel working on the various projects by completing the first part of the WAF for their waste streams. Using the information from the current inventory in the WAFs, a volume of 420,300 yds^3 of soil and debris from the various remedial actions selected in the Records of Decisions for WAGs 1, 3, 4, and 5. Also, a volume of 70,700 yds^3 of debris from D&D activities is being considered. This amounts to a total volume-requiring disposal of 491,000 yd^3 (see Table 2) without swell (from excavation/recompaction expansion, contingency, or increase due to treatment) is required to meet the identified waste stream projections. This information supports the ICDF landfill being designed and constructed based on the OU 3-13 ROD-authorized volume of 510,000 yd^3.

Historically, the volumes actually excavated from the remedial activities at the INEEL requiring disposal have not been as expected and have ranged between 75% and 300% of the estimated volume. This trend in the volumes is likely to continue during the implementation of the remedial actions. The disposal capacity of 510,000 yds3 for the ICDF landfill is 2 ft down from the top of the berm. There is a volume of approximately 217,600 yds3 (including the 2 ft to the top of the berm volume) that will be required to contour the landfill prior to installation of the engineered barrier structure (cap). This volume can potentially be used for disposal capacity, if the inventory disposed would remain within the ICDF landfill Waste Acceptance Criteria limits (DOE-ID 2002d).

As the ICDF was authorized in the OU 3-13 ROD to dispose of INEEL CERCLA wastes, waste from other projects on the INEEL could be a candidate for disposal in the ICDF if the waste was generated from a CERCLA action.

In developing the waste inventories, six different waste types have been identified and are used for the classification of the waste streams and associated volumes requiring either on-site or off-site disposal. These seven waste types include the traditional waste types of low-level waste (LLW), LDR compliant mixed low-level waste (MLLW - LDR compliant), non-LDR compliant mixed low-level waste (MLLW non-LDR compliant) LLW debris, MLLW debris, and Hazardous debris. These six waste types are generally described as follows:

LLW soils: Soils from the INEEL that have been contaminated with radionuclide concentrations exceeding the INEEL background values. LLW is waste that cannot be defined as high-level radioactive waste, spent nuclear fuel, transuranic (TRU) waste, by-product material [as defined in Section 11e (2) of the Atomic Energy Act of 1954, as amended] (42 USC 2011, et seq.), or naturally occurring radioactive material (DOE Order 435.1). LLW may contain transuranic (TRU) radionuclides up to less than a total of 100 nCi/g.

MLLW LDR compliant soils: Soils from the INEEL that have been contaminated with radionuclide concentrations exceeding the INEEL background values and that is designated as hazardous by EPA regulations (40 CFR 261.3) and that contains the hazardous components as defined by 40 CFR 262. However, the concentration of the hazardous constituents is less than the concentration required following treatment in accordance with 40 CFR 268.49. MLLW may contain transuranic (TRU) radionuclides up to less than a total of 100 nCi/g.

MLLW non-LDR compliant soils:	Soils from the INEEL that have been contaminated with radionuclide concentrations exceeding the INEEL background values and that is designated as hazardous by EPA regulations (40 CFR 261.3) and that contains the hazardous components as defined by 40 CFR 262. MLLW may contain transuranic (TRU) radionuclides up to less than a total of 100 nCi/g.
LLW debris:	Debris materials from the INEEL that have been contaminated with radionuclide concentrations exceeding the INEEL background values and that present an unacceptable risk to human health and the environment. LLW is waste that cannot be defined as high-level radioactive waste, spent nuclear fuel, transuranic (TRU) waste, by-product material [as defined in Section 11e (2) of the Atomic Energy Act of 1954, as amended] (42 USC 2011, et seq.), or naturally occurring radioactive material (DOE Order 435.1). LLW may contain transuranic (TRU) radionuclides up to less than a total of 100 nCi/g.
MLLW debris:	Debris materials from the INEEL that have been contaminated with radionuclide concentrations exceeding the INEEL background values and that present an unacceptable future risk to human health and the environment. MLLW is waste that meets the criteria for LLW, given above, and that contains hazardous components as defined by 40 CFR 262. MLLW may contain transuranic (TRU) radionuclides up to less than a total of 100 nCi/g.
Haz waste debris:	Debris materials from the INEEL that have been contaminated with waste that is designated as hazardous by EPA regulations (40 CFR 261.3) and that contains the hazardous components as defined by 40 CFR 262.

In determining the volumes for LDR and non-LDR compliant MLLW, it was assumed that during excavation activities it would be possible to segregate the waste requiring treatment (exceeds 40 CFR 268.49) from the waste not requiring treatment. This results in 20% of the waste being classified as non-LDR compliant and the other 80% as being LDR compliant. Also, evaluating the concentration of organic constituents (characteristic and listed waste constituents) showed that there are no organic constituents above the soil disposal standards (40 CFR 268.49), which would require treatment. The contaminants of concern are presented in Table 1 and the associated volumes are presented in Table 2. Classification of the waste streams in Table 2 used the knowledge of excavation and disposal standards.

Table 1. Contaminates and media type present at the release sites based on characteristics and process knowledge.

Release Site	Radio-nuclides	Listed Constituents	Potentially Characteristic							Comments
			Cd	Cr	Pb	Ag	Hg	Organics	PCB	
ARA-01	X									
ARA-12	X			X		X				
ARA-23	X									
CFA-04							X			Estimated 800 yd^3 does not meet TCLP values for Hg; remainder of site exceeds risk-based concentrations
CPP-01/04/05	X									
CPP-03	X									
CPP-08/09	X									
CPP-10	X									
CPP-11	X									
CPP-13	X	X								
CPP-14	X									
CPP-19	X									
CPP-34	X									
CPP-35	X	X					X			
CPP-36/91	X	X					X			
CPP-37A	X									
CPP-37B	X	X						X	X	Soil (75%) and debris (25%)
CPP-44	X			X	X		X			
CPP-48	X									
CPP-55							X			

Table 1. (continued).

Release Site	Radio-nuclides	Listed Constituents	Potentially Characteristic							Comments
			Cd	Cr	Pb	Ag	Hg	Organics	PCB	
CPP-67	X	X[a]					X			
CPP-69	X									Soil (5%) and debris (95%)
CPP-92	X	X					X			Soil (87%) and debris (13%)
CPP-93							X			
CPP-97	X	X								
CPP-98	X	X								Soil (12%) and debris (88%)
CPP-99	X	X								Soil (24%) and debris (76%)
TF CPP-28 IDW	X	X					X			
TF CPP-31 IDW	X	X								
CPP-83, Group 4	X	X								
CPP-88, NOD	X									
CPP-95, NOD	X									
OU 3-14	X	X					X			
Group 5	X	X								
TSF-06	X	X								
TSF-09/18, solidified liquid	X	X								
TSF-09/18	X	X								
TSF-26	X	X								

Table 1. (continued).

Release Site	Radio-nuclides	Listed Consti-tuents	Potentially Characteristic							Comments
			Cd	Cr	Pb	Ag	Hg	Organics	PCB	
WAG 1 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 2 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 3 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 4 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 5 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 6 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 7 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model
WAG 10 D&D&D										Contaminated debris with classification of waste streams based on the D&D&D Parametric Model

a. Potentially listed waste

Table 2. Waste type volumes for the release sites and D&D&D projects based on the classification of waste streams.[a]

Release Site	Volume (yd^3)	Volume LLW Soils (yd^3)	Volume MLLW Soils (LDR compliant) (yd^3)	Volume MLLW soils (non-LDR compliant) Soils (yd^3)	Volume LLW Debris (yd^3)	Volume MLLW Debris (yd^3)	Volume Hazardous Waste Debris (yd^3)
ARA-01	2,382	2,382	—	—	—	—	—
ARA-12	1,966	—	1,573	393	—	—	—
ARA-23	46,482	46,482	—	—	—	—	—
CFA-04	25,800	25,000	—	800	—	—	—
CPP-01/04/05	4,260	4,260	—	—	—	—	—
CPP-03	10,940	10,940	—	—	—	—	—
CPP-08/09	3,100	3,100	—	—	—	—	—
CPP-10	422	422	—	—	—	—	—
CPP-11	1,496	1,496	—	—	—	—	—
CPP-13	4,022	—	4,022	—	—	—	—
CPP-14	11,046	11,046	—	—	—	—	—
CPP-19	3,780	3,780	—	—	—	—	—
CPP-34	27,352	27,352	—	—	—	—	—
CPP-35	311	—	249	62	—	—	—
CPP-36/91	12,520	—	12,520	—	—	—	—
CPP-37A	10,889	10,889	—	—	—	—	—
CPP-37B	102,439	—	76,829	—	—	25,610	—
CPP-44	89	—	71	18	—	—	—
CPP-48	296	296	—	—	—	—	—
CPP-55	370	—	296	74	—	—	—
CPP-67	99,260	—	79,408	19,852	—	—	—
CPP-69	61	3	—	—	58	—	—
CPP-92	1,370	—	1,197	—	—	173	—
CPP-93	2,667	—	2,134	533	—	—	—
CPP-97	1,500	—	1,500	—	—	—	—
CPP-98	250	—	30	—	—	220	—
CPP-99	126	—	30	—	—	96	—
TF CPP-28 IDW	40	—	32	8	—	—	—

Table 2. (continued).

Release Site	Volume (yd^3)	Volume LLW Soils (yd^3)	Volume MLLW Soils (LDR compliant) (yd^3)	Volume MLLW soils (non-LDR compliant) Soils (yd^3)	Volume LLW Debris (yd^3)	Volume MLLW Debris (yd^3)	Volume Hazardous Waste Debris (yd^3)
TF CPP-31 IDW	40	—	40	—	—	—	—
CPP-83, Group 4	340	—	340	—	—	—	—
CPP-88, NOD	20,000	20,000	—	—	—	—	—
CPP-95, NOD	1,000	1,000	—	—	—	—	—
OU 3-14	800	—	640	160	—	—	—
Group 5	6	—	6	—	—	—	—
TSF-06	8,181	—	8,181	—	—	—	—
TSF-09/18, solidified liquids	80	—	80	—	—	—	—
TSF-09/18	4,365	—	4,365	—	—	—	—
TSF-26	10,216	—	10,216	—	—	—	—
WAG 1 D&D&D	5,211	—	—	—	5,205	4	1
WAG 2 D&D&D	6,834	—	—	—	6,829	4	1
WAG 3 D&D&D	38,718	—	—	—	38,672	37	9
WAG 4 D&D&D	0	—	—	—	—	—	—
WAG 5 D&D&D	13,954	—	—	—	13,941	10	3
WAG 6 D&D&D	0	—	—	—	—	—	—
WAG 7 D&D&D	5,942	—	—	—	5,938	3	1
WAG 10 D&D&D	0	—	—	—	—	—	—
Total	490,923	168,448	203,759	21,900	70,643	26,156	16

4. ON-SITE DISPOSAL COST ESTIMATE

The cost estimate for on-site disposal is comprised of four major cost elements or phases. These major cost elements are (1) capital costs, (2) operations costs, (3) closure costs, and (4) post-closure costs. Each of these major cost elements has sub-element cost components. For this analysis, cost estimates are presented in terms of the major cost elements. The detailed cost estimate for on-site disposal, including the sub-element cost components, is presented in Appendix C.

This cost estimate is the Final ICDF and SSSTF Remedial Design/Construction Work Plans (DOE-ID 2002a, 2002b) concerning the design and construction activities. The operations, closure, and post-closure care are based on the information contained in the Draft ICDF Complex Remedial Action Work Plan (DOE-ID 2002e). There are several major components that comprise the ICDF Complex: (1) road work, (2) utilities, (3) administration facility, (4) scales facility, (5) decontamination facility, (6) treatment equipment, (7) ICDF landfill cells, (8) ICDF evaporation pond, (9) ICDF operating equipment, and (10) a waste tracking system.

The roadwork consists of constructing a new road from Lincoln Boulevard to the INTEC perimeter road and into the ICDF Complex. The utility work consists of installation of the water, sewer, communications, and fire protection from INTEC to the ICDF Complex and the installation of electrical power from overhead power lines into the ICDF Complex. The administration facility is a small modular building that will contain offices, a conference room, waste tracking equipment, and restroom facilities. A scale large enough to weigh a loaded truck at one time composes the scale facility. The decontamination facility is a preengineered metal building that will be used for decontamination of equipment, change rooms, restroom facilities, and housing of both the soil stabilization and debris treatment operations. The treatment equipment is the soil stabilization equipment. The ICDF landfills cells consist of an expandable landfill cell that, when completed, will have a disposal capacity of 510,000 yd^3. The ICDF evaporation pond is sized to deal with the expected leachate from the ICDF landfill cells and other liquid waste streams. The waste tracking system, which is part of the administration facility, is being developed to track the waste through the ICDF Complex, for inventory control, and for compliance with the waste acceptance criteria at the ICDF Complex. Figure 1 shows the layout of the ICDF Complex.

In the cost estimate for on-site disposal at the ICDF Complex, the cost items have been arranged into five major cost items for the cost estimate. The scope of each of these five major cost items is discussed below. The cost estimates are based on the final design and construction documents (DOE-ID 2002a, 2002b) along with the approaches for operations, closure, and post-closure care presented in the ICDF Complex RA WP (DOE-ID 2002e). The scope of the four major cost elements is discussed below. The specific scope used to estimate the activities is discussed in Appendix G.

Capital costs: These include the project documentation (RD/RA SOW, design document, waste acceptance criteria, etc.), procurement, work authorization, construction, quality assurance/quality control, and project management necessary for the construction of the various facilities composing the ICDF Complex. Also, the operating equipment and startup activities are included in the capital costs.

Operations costs: These include the ICDF Complex operations (ICDF landfill and evaporation ponds operations, leachate management, and 10 years of treatment operations), records management/maintenance, and project management necessary to operate the ICDF Complex in compliance with the design and operational requirements.

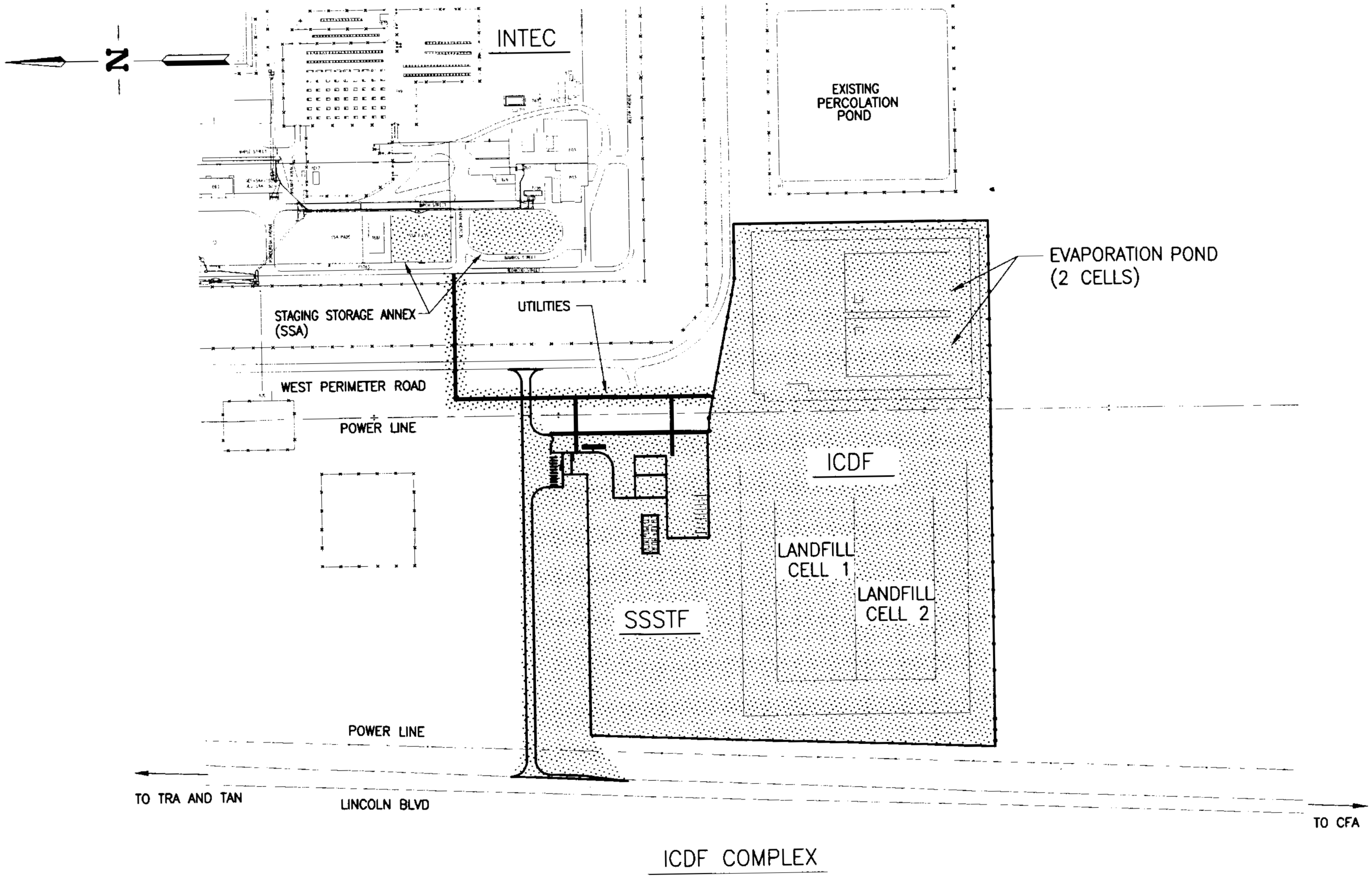

Figure 1. Plain view layout drawing showing the major facilities that compose the ICDF Complex.

Closure costs: These include the D&D&D of the SSSTF facilities, constructing an engineered containment barrier (cap) over the ICDF landfill cells, record management/maintenance, and the project management necessary to close the facilities in compliance with the design and closure requirements. (about 2 years)

Post-closure costs: These include aquifer monitoring (sampling and analysis) through the year 2095, maintenance of the engineered barrier structure (cap), maintaining institutional controls, records management/maintenance, and project management necessary to implement these programs.

These summary-level cost elements are presented in Table 3. Details concerning the cost elements and sub-elements are presented in Appendix C and Appendix G contains the scope and assumptions used to develop the cost estimate.

Table 3. Summary cost estimate for on-site disposal at the ICDF Complex, including the four major cost elements along with the total estimated cost for on-site disposal.

Cost Elements	Current Cost Estimate (2002 dollars)
Capital	$46,852,000
Operations total	$26,046,000
Closure total	$13,867,000
Post-closure total	$9,212,000
Grand total	$95,977,000

5. OFF-SITE DISPOSAL COST ESTIMATE

The cost estimate for off-site disposal is comprised of four major cost elements or phases. These major cost elements are (1) capital costs, (2) operations costs, (3) closure costs, and (4) post-closure costs. Each of these major cost elements has sub-element cost components. For this analysis, cost estimates are presented in terms of the major cost elements. The detailed cost estimate for off-site disposal, including the sub-element cost components is presented in Appendix E.

This cost estimate is based on using the information contained in the final SSSTF RDCWP (DOE-ID 2002b) and other information as necessary. In conducting the cost analysis for the on-site disposal remedy, several of the issue and functions necessary for handling the waste are applicable to either on- or off-site disposal. Using the information and cost estimates from the on-site disposal project along with other assumptions, a cost estimate for off-site disposal has been developed.

For the evaluation of offsite site disposal, two alternatives were considered. The first alternative is similar to the alternative evaluated in the OU 3-13 Feasibility Study in that the waste would be loaded onto railroad cars and sent to an offsite commercial disposal facility. The second alternative would also dispose of the waste offsite, but would include additional onsite facilities for the treatment of the waste prior to shipment for offsite disposal.

The first alternative (offsite treatment and disposal) would be comprised of several major components that would necessary for an off-site shipping facility: (1) road work, (2) utilities, (3) administration facility, (4) scales facility, (5) decontamination facility, (6) railroad spur, and (7) a waste tracking system. The second alternative (onsite treatment and offsite disposal) would include the components of the first alternative along with soils, debris, and aqueous waste treatment equipment/systems.

The roadwork consists of constructing a new road from Lincoln Boulevard to the INTEC perimeter road and into the ICDF Complex. The utility work consists of installation of the water, sewer, communications, and fire protection from INTEC to the ICDF Complex and the installation of electrical power from overhead power lines into the ICDF Complex. The administration facility is a small modular building that will contain offices, a conference room, waste tracking equipment, and restroom facilities. A scale large enough to weigh either a loaded railroad gondola car or a loaded truck at one time composes the scale facility. The decontamination facility is a preengineered metal building that will be used for decontamination of equipment, change rooms, and restroom facilities. A railroad spur would be dedicated to loading and shipping waste off-site by railroad cars. The waste tracking system, which is part of the administration facility, is being developed to track the waste through the ICDF Complex, for inventory control, and for compliance with the waste acceptance criteria of the off-site disposal facilities. Figure 2 shows the conceptual layout for both offsite disposal alternatives. However, the treatment equipment would be located in the decontamination facility.

The cost estimate for off-site disposal is comprised of the same four major cost elements as the estimate for on-site disposal at the ICDF Complex. The scope of each of these four major cost items is discussed below. The cost estimate is based on the projects being implemented as described in the Final SSSTF RD/CWP (DOE-ID 2002b) along with the associated cost estimates. The scope of the four major cost elements is discussed below. The specific scope used to estimate the activities is discussed in Appendix G.

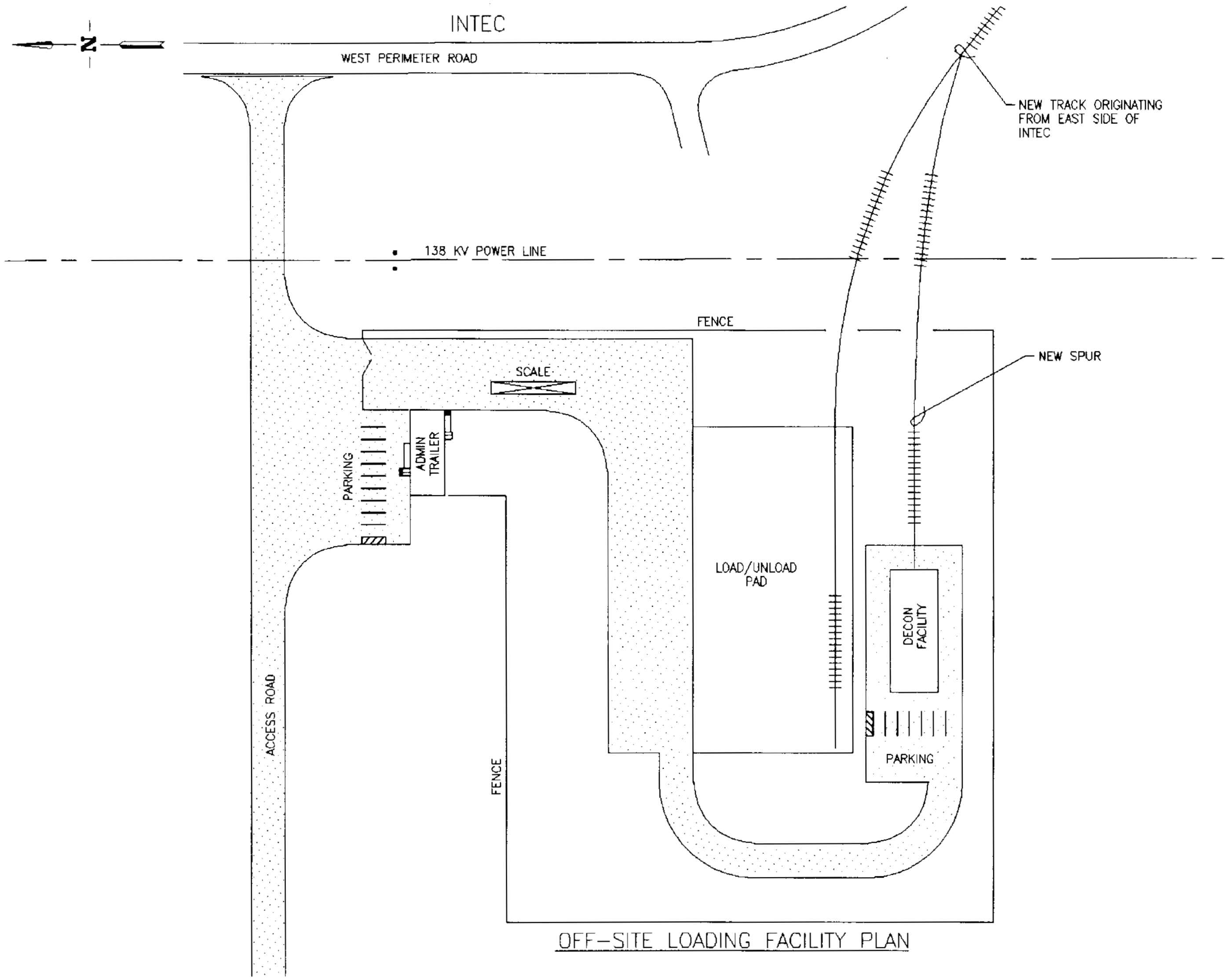

Figure 2. Plan view conceptual layout drawing showing the major facilities that would comprise the off-site shipping facility **(need to add another rail line next to fence for staging loaded railroad cars)**.

Capital costs : These include the project documentation (RD/RA SOW, design document, waste acceptance criteria, etc.), procurement, work authorization, construction, quality assurance/quality control, and project management necessary for the construction of the various facilities (administration facility, decontamination facility, loadout facility [large concrete pads], etc.) composing the off-site shipping facility. Also, the equipment and startup activities are part of capital costs.

Operations costs: These include off-site shipping facility operations (loading, sampling, transportation to the off-site disposal facility, and disposal at the off-site disposal facility), records management/maintenance, and project management necessary to operate the off-site shipping facility in compliance with the expected design and operational requirements. Also, the treatment costs for the onsite treatment with offsite disposal alternative is part of operations cost.

It should be noted that during the development of the OU 3-13 ROD, the reevaluation of cost would use the existing contract without speculation as to what new rates could be negotiated for off-site disposal.

In developing the current updated cost estimate for off-site disposal, an existing contract with Envirocare (Envirocare 1998) and set of rates received from Jeff Shadley, DOE-ID, (Shadley 2001) based on other existing contracts were used. In this contract, there are various unit rates for disposal of different types of wastes. For transportation rates, an existing report (LMITCO 1995) was used. In this document, there are different rates for different modes of transportation (rail or truck). The rate for truck is much larger than for rail with a destination of the off-site disposal facility considered (Envirocare). As such, the updated cost estimate for off-site uses the rail transportation rate.

Closure costs: These include the D&D&D of the off-site shipping (treatment facilities for onsite treatment) facilities, records management/maintenance, and the project management necessary to close the facilities in compliance with the design and closure requirements. D&D&D of the rail spur was not included.

Post-closure costs: No post-closure costs were included for the off-site shipping facility.

These summary-level cost elements are presented in Table 4 for offsite treatment and disposal alternative. Details concerning the cost elements and sub-elements are presented in Appendix E and Appendix G contains the scope and assumptions used to develop the cost estimate.

The summary-level cost elements are presented in Table 5 for the onsite treatment with offsite disposal alternative. Details concerning the cost elements and sub-elements are presented in Appendix E and Appendix G contains the scope and assumptions used to develop the cost estimate. However, in order for this alternative to be success and implementable, the offsite disposal facility would be accepting waste treated onsite along with the development of no-longer contained in determinations that would require several States and at least two EPA regions to agree to the determinations. In addition, the offsite disposal facility would paid for disposal of the waste (treated waste) at the low-level waste rate for soils and debris. This means that the waste streams would be essentially "delisted" from a RCRA perspective.

Table 4. Summary cost estimate for off-site treatment and disposal, including the four major cost elements along with the total estimated cost for off-site disposal.

Cost Elements	Current Cost Estimate (2001 dollars)
Capital	$17,931,000
Operations total	$515,501,000
Closure total	$3,925,000
Post-closure total	$0
Grand total	$537,357,000

Table 5. Summary cost estimate for onsite treatment with off-site disposal, including the four major cost elements along with the total estimated cost for off-site disposal.

Cost Elements	Current Cost Estimate (2001 dollars)
Capital	$23,688,000
Operations total	$162,404,000
Closure total	$4,183,000
Post-closure total	$0
Grand total	$190,276,000

6. CONCLUSIONS

This section presents two types of comparisons for the cost of on-site versus off-site disposal of INEEL CERCLA waste. The first comparison is the cost of disposal including all costs associated with each of the four major cost elements as discussed above in Sections 4 and 5. In this comparison, the cost of on-site disposal is less than one-fifth the cost of off-site treatment and disposal ($96 million versus $537 million) and one-half the cost of onsite treatment with offsite disposal ($96 million versus $190 million).

The second comparison is the cost of disposal per cubic yard of waste. For on-site disposal, the current estimate and FS Supplement Report estimate consider both the volumes of waste expected to be disposed without swell and the design volume for the ICDF. In the case of the off-site disposal option, both the current and FS Supplement Report estimate use the volumes expected to be disposed at the time of analysis without swell. Also, the evaluation considered the volume that would be used to contour the landfill prior to installation of the engineered barrier structure (cap). This analysis is presented in Table 6.

Table 6. Comparison of the cost of on-site versus off-site disposal for both the current and FS Supplement Report estimates along with the calculated cost of disposal per cubic yard.

	Current Onsite Estimate	FS Supplement Onsite Estimate	Current Offsite Treatment and Disposal Estimate	Current Onsite Treatment and Offsite Disposal Estimate	FS Supplement Off-Site Estimate
Cost ($)	95,977,000	234,417,000	537,357,000	190,276,000	712,846,000
Expected Disposal volume (yd3)	490,923	465,307	490,923	490,923	465,307
ICDF design volume (yd3)	510,000	510,000	NA	NA	NA
ICDF design volume using contour volume (yds3)	727,600	727,600	NA	NA	NA
Average cost of disposal for expected inventory ($/yd3)	196	504	1095	388	1532
Average cost of disposal for ICDF design volume ($/yd3)	188	460			
Average cost of disposal for ICDF also using contour volume ($/yd3)	132	322			

As can be seen in Table 6, the costs of both on-site and off-site disposal have been significantly reduced.

Other comparisons illustrate the reductions in the cost of disposal for both on-site and off-site. For example, Table 7 presents the reduction in the cost of both on-site and off-site treatment and disposal from the time the FS Supplement was issued to the current time. As the table shows, both on-site and off-site treatment and disposal costs have been significantly reduced. This analysis shows that it is possible to reduce the cost of off-site disposal by 25% while using the correct waste types versus the GAO reduction of 22% by assuming that all of the waste is low-level waste. However, the cost of on-site disposal has been reduced to a much larger extent than for off-site disposal.

This last analysis shows that the ratio of cost between off-site versus on-site disposal has increased from approximately three times more expensive for off-site at the time the FS Supplement was issued to over five times more expensive today.

The cost of off-site treatment and disposal could possibly be further reduced, but this would require additional characterization data and different assumptions concerning the waste types. This possibility was examined and the cost estimate was $190 million, but would require the disposing facility to accept the waste treated onsite as low-level waste and delisting of the waste streams. However, the offsite commercial disposal facility would only be paid for waste being disposed under this alternative as low-level waste instead of the higher priced mixed low-level waste. This may be a future financial incentive, but the cost to the disposing facility would be considerably higher due to the type of facility (landfill) required for disposal of mixed low-level waste. However, it is not conceivable that the cost of off-site disposal could be reduced to the current cost of on-site disposal at the ICDF Complex.

Table 7. Comparison of the cost of on-site versus off-site disposal for both the current and FS Supplement Report estimates along with the calculated reductions in cost and the ratios of off-site to on-site disposal.

Current on-site estimate	$95,977,000
FS Supplement on-site estimate	$234,417,000
Current off-site treatment and disposal estimate	$537,357,000
FS Supplement off-site estimate	$712,846,000
Cost reduction for on-site disposal from FS Supplement to current cost estimate	59%
Cost reduction for off-site disposal from FS Supplement to current cost estimate	25%
Ratio of off-site treatment and disposal to on-site disposal using current estimate	5.6:1
Ratio of off-site to on-site disposal using FS Supplement	3.0:1

7. REFERENCES

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